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Heating Piping & Air Conditioning

INDUSTRIAL
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SEPTEMBER ★ 1947

DESIGN
INSTALLATION
OPERATION
MAINTENANCE

e 121 — Journal Section of the American Society of Heating and Ventilating Engineers

Extended study was given the Metropolitan Life's apartment projects. Their heating features are described on pages 77-82

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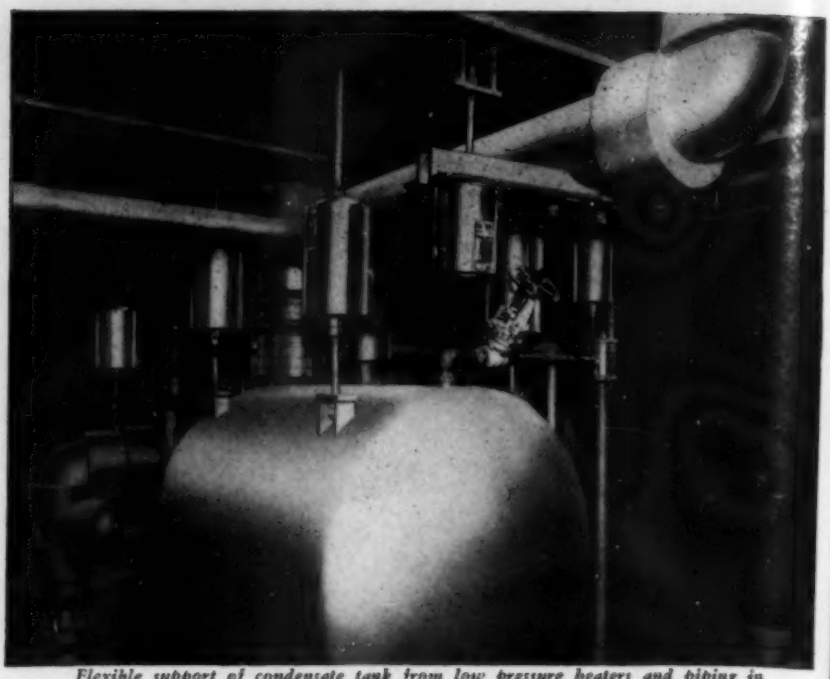
FLEXIBLE SUPPORT OF PIPING

made easy for you



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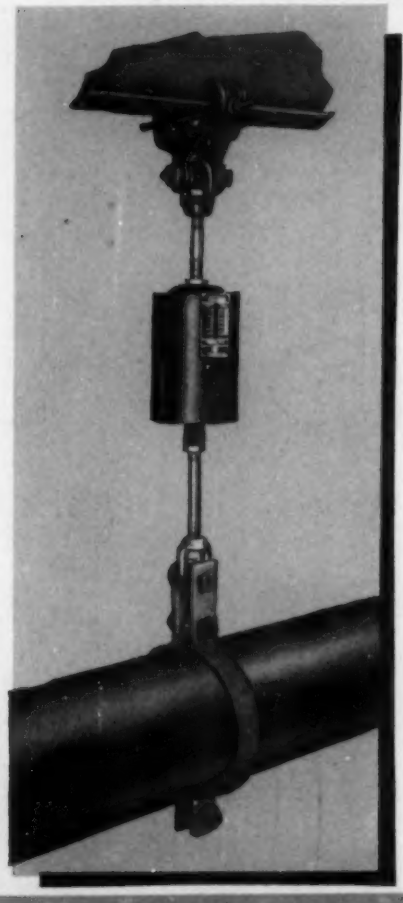

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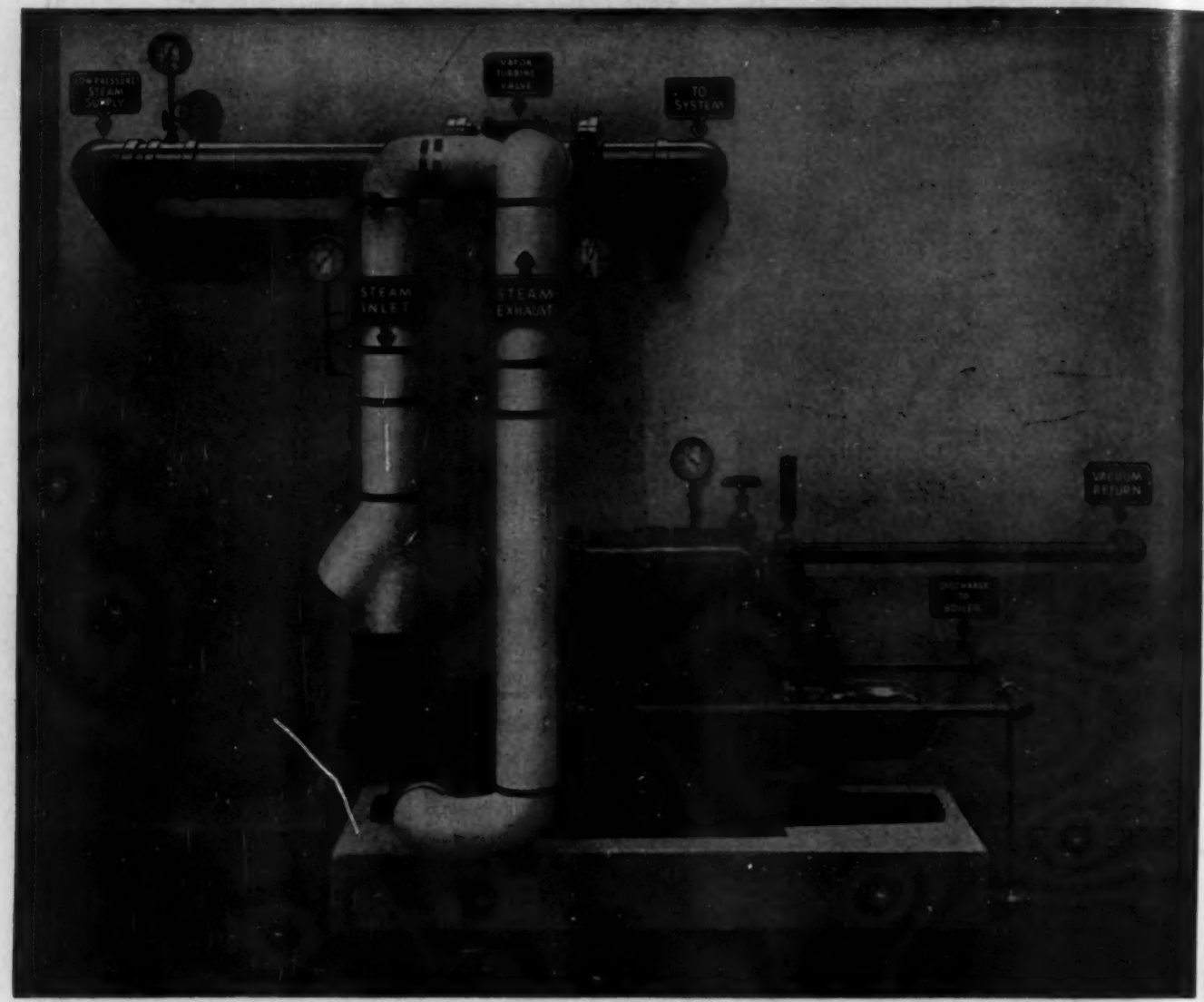
Interrupted Electric Service will not stop this NASH Heating Pump



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Lewis Smith and William Bessler Tell of Features of Three New Apartment Housing Developments

Heating the METROPOLITAN LIFE APARTMENT PROJECTS

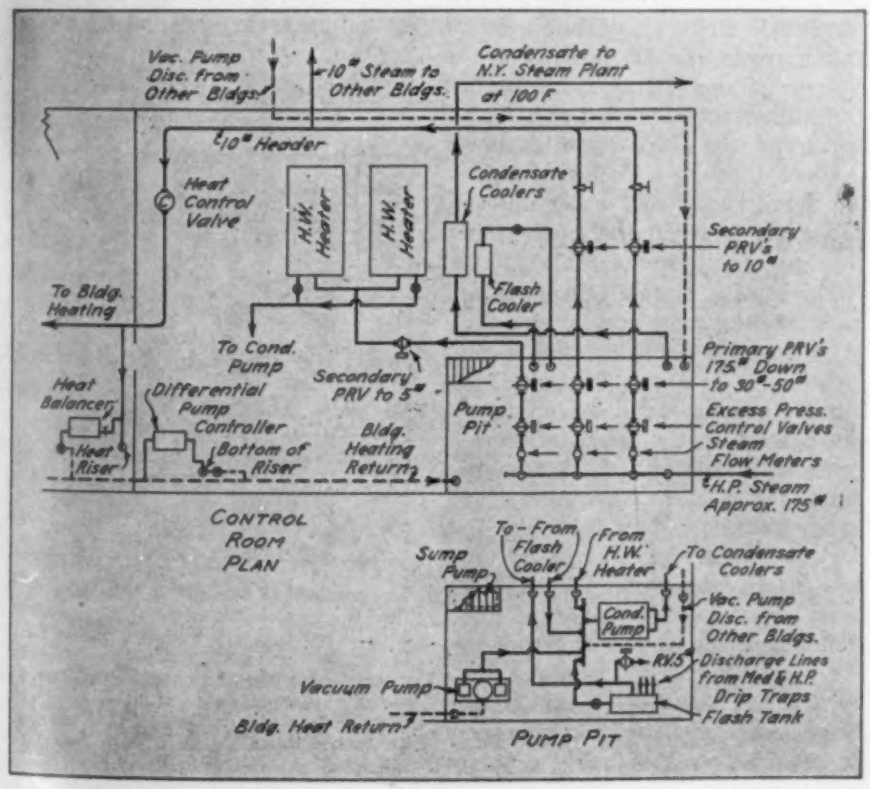
THE METROPOLITAN Life Insurance Co., which had entered the field of large-scale rental housing after the first world war, undertook in 1938 the execution of a housing plan without parallel in the United States. This was the construction of Parkchester, in New York City, for 12,272 families (about 35,000 persons).

Its completion was followed by the building of apartment communities in other parts of the country. In each case the decision to build had three aims—to meet public need for housing, to create jobs for men who needed them in the building trades, and to make sound investment. These communities—as in the case of Parkchester—embodied modern concepts of apartment living and today have long waiting lists. They are Parkfairfax, 1684 families, Alexandria, Va.; Parklabrea, 1316 families, Los Angeles; and Parkmerced, 1687 families, San Francisco.

Metropolitan Life is now engaged in constructing three residential communities for almost 12,500 families in Manhattan. Unlike the communities already mentioned, which were built on unimproved land, these necessitated the demolition of old city blocks (30 in number), many of them burdened with obsolete tenements.

The extraordinary scale upon which construction was planned necessitated extended study and deliberation. Hence, what is done on these jobs is of more than usual interest to the building trade. This article describes the more important features of the heating systems.

There are 14 control rooms in various buildings of Stuyvesant Town. This sketch shows the equipment arrangement in a typical control room



31,450 Convectors in Three Projects

Stuyvesant Town has 35 buildings approximately 13 stories high, housing 8755 families, mainly in units of one, two, and three bedrooms. The buildings are made up of multiples of basic cross-shaped units, many of them joined in groups up to five units. There are 22,100 convectors having 400,000 sq ft of equivalent direct radiation and a total heat requirement of 660,000 sq ft including all exposed risers. There will be stores, branch banks, etc., along 14th and 20th Sts. and 1st Ave. There are six garages for tenants with a total capacity of almost 2000 cars; these are slightly below grade, one story, and are decked over to provide playgrounds and landscaping overhead.

Peter Cooper Village comprises 21 identical buildings 15 stories high, housing 2495 families in apartments consisting of one bedroom and bath and two bedrooms with two baths. There are 6300 convectors having 182,000 sq ft of heating surface.

Riverton consists of seven buildings housing 1232 families in units

OF MORE THAN usual interest is a description of the method of heating Stuyvesant Town, Peter Cooper Village, and Riverton—three new projects of the Metropolitan Life Insurance Co. in New York City. Because of the extraordinary scale on which construction was planned, extended study and deliberation was needed. The authors (with C. A. Dunham Co. and Baker, Smith & Co., Inc., respectively) explain in detail the heating system for Stuyvesant Town, as the systems within the buildings for all three projects are practically identical. Stuyvesant Town and Peter Cooper Village are supplied steam by the New York Steam Corp., while Riverton has a unique oil fired plant

of one and two bedrooms. There are 3050 convectors having 55,500 sq ft of heating surface.

The heating systems within the buildings on all three jobs are practically identical. Riverton has a unique oil burning, low pressure central steam plant; Stuyvesant Town and Peter Cooper both receive steam from the New York Steam Co. These two are also practically identical, so this article will describe details of the heating system for Stuyvesant Town only.

The New York Steam boiler plant is only one block from the southeast corner of the property. In 14th St., which borders the property, is a 24 in. main carrying steam at about 175 lb pressure. At 14 points, branches are taken off this main and connected to 14 control rooms in various buildings. From each such control room steam is distributed at 10 lb to the heating system control stations in each building, where the heat control valves and vacuum pumps are located.

Fourteen Control Rooms

The arrangement of equipment in a typical control room is schematically shown in an accompanying sketch. Steam passes from the high pressure header through the New York Steam Co.'s flow meters. There is one meter for the water heaters and two other meters for heating steam, one for light load and one for heavy load—although both might be used in extreme weather. Reduction is first made to 30, 40, or 50 lb, depending on the load or service. Secondary valves then reduce to 5 lb for the water heaters in the control rooms and 10 lb for heating.

To guard against excess pressure due to failure of the reducing valves to operate properly, a pressurestat control is connected to the low pressure header which will cause a motor operated valve between the flow meter and the primary reducing valve to close in case the low pressure rises up to 15 lb. In this way a large safety valve and blowoff pipe to the roof are eliminated.

From the 10 lb header, one branch feeds through the control valve to the heating system in that building, and one or more other branches feed into the underground mains going to other buildings.

Hot water heaters are confined to the fourteen control rooms and distribution of hot water to adjacent buildings is done by lines run through the garages or underground in conduits similar to the steam lines, as described later.

All 5 lb drips go through float and thermostatic traps to a condensate pump. Drips from 10 lb and higher are connected to a flash tank, and the flash steam is discharged through a cooler containing a coil in the cold water line to the water heaters, the condensate then going to the condensate pump.

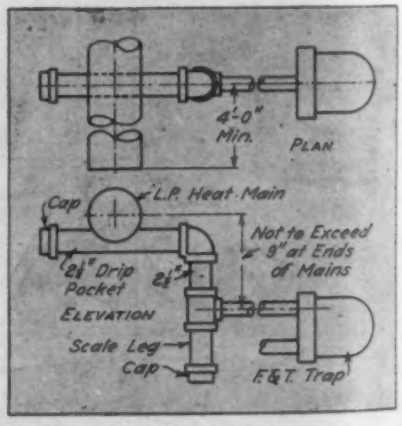
The heating system returns from each building come back by gravity to a vacuum pump in the same building. This pump discharges into the condensate pump in one of the control rooms, which likewise receives the discharge from vacuum pumps in adjacent buildings. The pump discharge lines from the 14 control rooms, together with the condensate from Peter Cooper Village, are joined together at the building at the southeast corner of the property and tied into one line back to the New York Steam plant. It is calculated that 15 lb pressure is required at the junction point and the various pumps scattered over the property are designed for 40 lb discharge pressure.

The method of installing drip traps on the low pressure heat mains is unusual. The arrangement is shown in an accompanying sketch. The 2½ in. pipe is welded into the steam main and provides a reservoir for condensate during the heating up period and creates an extra head on the traps without blocking the mains with water.

The 10 lb distribution mains connecting the buildings are generally run at the underground garage ceilings, and under the ground where garages are not available. The underground piping is enclosed in conduit with tile or cast iron cover, with concrete base and sides with internal drain in the base. These conduits generally include the 10 lb steam main, which is insulated, and the vacuum pump discharge lines. The condensate pump discharge lines are installed in the same manner. All pump discharge lines in conduits are brass piping.

Heating System a Major Decision

A major decision had to be made as to the type of heating system to be used within the buildings. The three projects comprise 63 buildings with 31,450 radiators and 637,500 sq ft of radiation. Obviously a large investment of money is involved and fully as important is the annual operating cost, where a few per cent one way or the other runs into real money. Then there is to be considered the comfort and sat-



The method of installing drip traps on the low pressure mains is unusual. This is a detail for ends of mains and in general runs. The 2½ in. pipe is welded into the steam main and provides a reservoir for condensate during the heating up period and creates an extra head on the traps without blocking the mains with water

isfaction of over 40,000 persons expected to live in these apartments. It was only natural that the results at Parkchester should be the guide and these results were found to be exemplary. Studies were made of other systems, and especially of improvements which might have been made since Parkchester was installed about eight years ago. With all these factors considered, the decision was made to continue with the Metro piping scheme as used at Parkchester, with modifications in some construction and installation details.

The essential departure from conventional piping practice is the use of a single pipe (called the Metro riser) passing through a number of overlying rooms, this riser being offset in each room, and these offsets being the heating elements of convectors of a special design. The Metro riser is supplied with steam at the top from an adjacent heat riser or an attic steam main. It is dripped through a trap in the basement into a return main. The vertical sections of the Metro riser are best located close to and on alternating sides of the window openings, permitting direct connection by straight pipe from one convector to the next and the setting of these convectors below the windows where they are most effective. The steam risers, being located in the bathrooms or kitchens, are usually 2 or 2½ in. diameter for heating effect and are of ample size to supply steam not only to one Metro riser but to several of them.

The next step was design of the convector. The general design used at Parkchester was followed but a heating element of finned steel pipe was found to be more flexible and adaptable, as well as being easier to install. To keep tenants from standing on the cabinets or covering up the grilles with magazines, etc., a sloping top was adopted. This also permitted supporting the cabinets from the window stool instead of anchoring them to the walls, with a considerable saving in installation cost and an improvement in appearance.

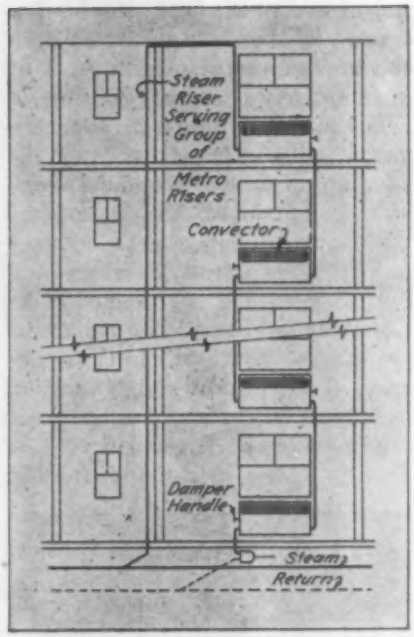
All bathrooms and kitchens are heated by 2½ in. risers. The tops of these risers are connected to the tops of downfeed Metro risers at each tier of livingroom and bedroom windows as shown in an accompanying sketch. The downfeed Metro risers are uniformly 1½ in., except in Peter Cooper, where some risers carry loads of over 600 sq ft and are 2 in. Each Metro riser is located close to the edge of the window frame and is exposed. Being painted the same color as the walls, these risers are not obvious. The low average steam temperature, around 160 deg, prevents harm to draperies or sooting of the walls.

Construction of the Convectors

The convectors are composed of a back, a front with damper, and a heating element. The cabinets are made the full width of the window, regardless of the amount of radiation, presenting a pleasing appearance and permitting standardization of both manufacture and installation—in addition to eliminating any horizontal exposed piping in the rooms. The back has a flange at the top edge which is hooked to the steel window stool and is clamped there by a sliding brace and bolts so arranged as to leave a slot into which the top edge of the front fits. The bolts extend through the back and press against a wood ground to hold the back tight against the sill. The bottom edge of the back is offset to come in front of the wood screed at the floor line and is fastened there with wood screws. Thus no support to the walls is needed. The vertical edges of the back are flanged to serve as plaster stops and for attaching the front by screws. There is no plaster behind the cabinet.

The Metro Piping

The heating element is a standard steel pipe with fins pressed on and interlocked in place for such length as is required for the heating effect in the particular location. The pipe is not supported on the cabinet or wall but rests on a sleeve at the return end as shown in one of the sketches. This sleeve is a piece of steel tubing slightly larger than the riser pipe over which it is slipped by the fitter who has sleeves of varying lengths to compensate for any minor deviation in story heights. No anchors or expansion joints are required in these Metro risers; the slight expansion of about 1/10th in. between floors is absorbed by the flexing of the piping around the support as a fulcrum.



Bathrooms and kitchens are heated by 2½ in. risers, the tops of which are connected to downfeed risers at each tier of livingroom and bedroom windows

The Metro riser sections are all cut the same length and can be cut and threaded in a shop ahead of time. Except where the fin length is too great, the heating element pipe is terminated 4½ in. inside the cabinet at one end to make room for a union which is an aid in assembling the risers. The other end of the pipe projects 1 in. beyond the cabinet so that the elbow will line up with the riser.

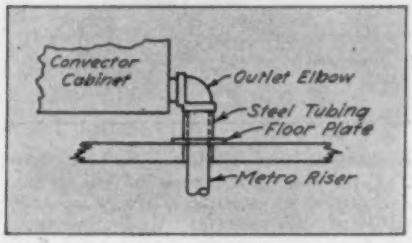
The usual procedure is that the backs are set before plastering. The risers and heating elements are then installed, usually from the first floor up. It is not essential that the plastering be done first—the piping can be done after plastering if necessary, which is often a big help in scheduling a large job. Meantime the heating elements can be used for temporary heat without setting temporary radiators, an economy in overall construction costs.

There are no radiator branches. With wood flooring laid on mastic directly on concrete floor slabs, the problem of where to put branches is a difficult one. Running them exposed along the baseboard is objectionable in every way. To hang them on the ceiling below means the extra cost of furring them in

and of additional floor sleeves. Recessing in the walls would be difficult and expensive. Getting rid of them entirely is an easy solution.

In addition, eliminating branches means eliminating labor and the handling of a huge volume of small pipe and fittings. The absence of those small fittings cuts out the most prolific source of leakage and corrosion. With the reduction in pipe volume, these Metro systems are remarkably tight and easily operate at exceptionally high vacuum.

The bathroom and kitchen heat risers serve the double purpose of heating those rooms and feeding



The pipe is not supported on the cabinet or wall but rests on a sleeve at the return end

steam to the tops of one or more Metro risers. They are usually located behind doors away from the outside wall and, being well towards the center of the building, a single main in the basement can be used with branches to the heels of the risers, back graded to the main. This simplifies the mains and further reduces costs.

The bottoms of the downfeed Metro risers are dripped through float and thermostatic traps. There are no valves and no traps at the convectors. All traps are in the basement. On Stuyvesant Town, instead of 22,100 radiator traps to service, necessitating entry into occupied apartments, there are only some 1700 traps—all in the basement, where they can be serviced at any time. The saving in annual maintenance cost is obvious. Then, too, if there is steam down to the trap, the operating man knows that there is heat at every radiator in the riser, so he doesn't have to go up into the building to see about that.

Pressure Drop, Evenness of Heating

The pressure drop and evenness of heating in these Metro risers have been often questioned. At first glance, it would seem as if a 1½ in. riser over 120 ft long passing successively through 15 radiators of 30 sq ft each must have a high pressure drop which would cause unequal heat between the top and bottom convector. Tests made on jobs already in operation show that with 2 lb steam pressure at the top of the riser, there is not over ½ lb loss from top to bottom, and that at 25 in. of vacuum the loss is approximately ¼ lb. In either case, the difference in heat output is negligible.

The function of the drip trap at the bottom of the Metro riser is to keep the riser clear of water and air, and full of steam under all conditions of pressure or high vacuum. With a total riser load of, say, 500 sq ft EDR the maximum rate of condensation at 2 lb pressure is only 1 quart of water per minute and this diminishes rapidly under vacuum until there is only half a pint coming back. This is a stream smaller than the lead of a pencil. The trap is of ample capacity to take care of this easily. Then, too, the condensate descending through the riser is always in contact with the steam and hence is at about steam temperature, so the capacity of even the bottom convector is not diminished.

How Heating Is Controlled

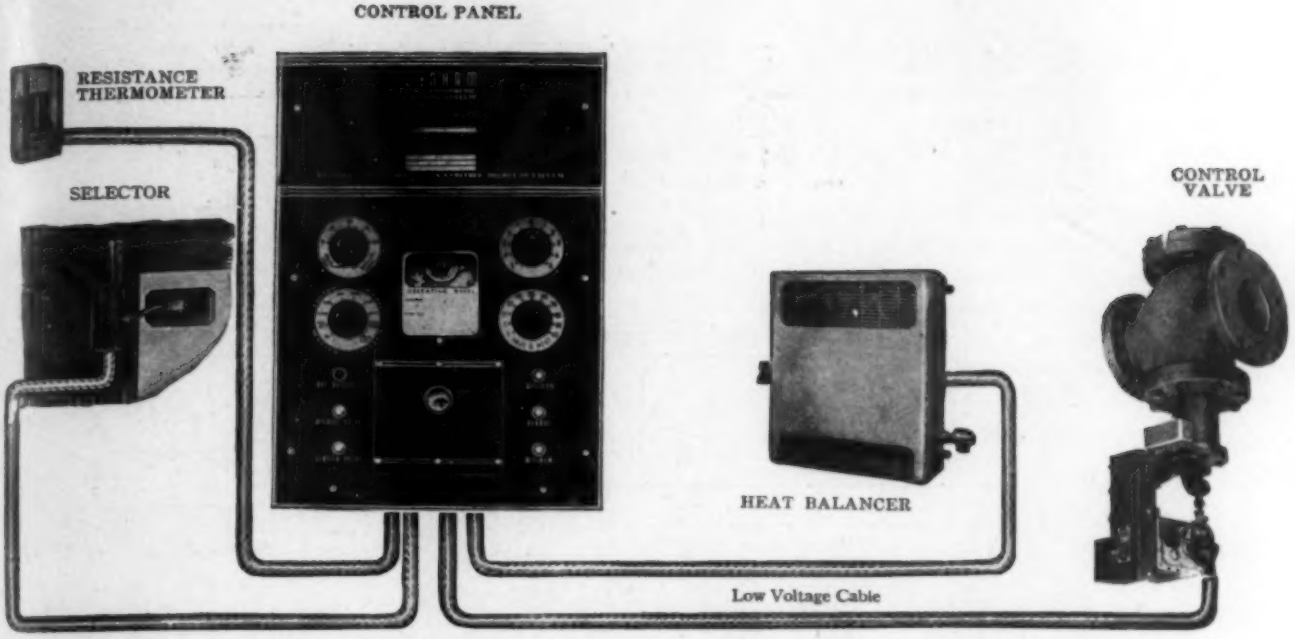
As to control of the heat in the rooms, it is plain that with radiators in series, no one radiator can be shut off, nor can orifice plates be used. It becomes necessary then to rely entirely on control of the steam temperature in the convectors and keep them continuously full of steam. This is done by means of subatmospheric steam control, wherein the pressure is varied in step with the heat loss from 2 lb above atmosphere to 25 in. and more below atmosphere. Actual steam temperatures in the convectors as low as 125 deg are often noted, but ordinarily need not be carried below 133 deg. This range of steam temperatures from 218 to 125 deg, when considered in connection with the performance of a convector which varies its output of heat not directly as the temperature difference between the steam and surrounding air but as the three-halves power thereof, provides fully adequate control up to an outside temperature of 60 deg at which point it is quite customary to shut off the heat entirely.

The control of steam temperatures is effected through the use of an automatic control valve in conjunction with traps which operate up to 25 in. of vacuum or more, and vacuum pumps automatically controlled to produce a constant differential between the steam and return mains and evacuate air and water from the system at the high vacuum required.

The control valve is of the double seated balanced type with a reversing motor. A heat balancer is installed at some point along the steam main, consisting of a small convector having electrical resistance coils, one below the heating element to measure incoming air temperature, the other inside the cabinet above the heating element, so that the difference in resistance between the two coils is a measure of the temperature rise of the heated air, and therefore a measure of the performance of the convectors in the building for any given steam temperature. Another resistance coil—called the selector—is placed against a north-facing window to measure the outdoor temperature. This coil is also sensitive to wind velocity and to some extent is affected by the room temperature. Control valve motor, heat balancer, and window thermostat are all connected to a panel. This panel contains a galvanometer and a synchronous timing device, which causes a contact to be made three times a minute for a few seconds. During this brief time of contact the various resistances mentioned above are connected into the galvonometer circuit and cause deflection of a needle, which results in moving the control valve slightly in one direction or the other (or no movement at all if all resistances are in proper balance).

Normal Cycle of Operation

The cycle of operation is best understood by taking the normal procedure for a day. The control valve is first opened practically fully to give quick circulation of steam and ample pressure for heating up the building after night shutdown. The valve is then placed under automatic control. With the system full of steam at practically 1 lb pressure, the first action of the control



It is necessary to rely entirely on control of the steam temperature in the convectors and keep them continuously full of steam. The method of control is described in detail in the text

on a normal winter day is to call for much less heat and cause the valve to step slowly towards the closed position. This means that less steam is being admitted than the system is condensing, and a vacuum appears in the system. The differential controller attached to the pump and connected to the inlet and outlet sides of a drip trap on the bottom of a Metro riser is set to maintain a practically constant differential across the system. The building up of the vacuum in the system tends to kill the differential but the controller keeps the pump running sufficiently to maintain it. As the control calls for less and less heat the vacuum continues to build up and the steam temperature continues to go down until the proper balance for that particular time is reached. Thus, for any outside temperature or wind condition there is a definite valve position, vacuum, and steam temperature, and that is the crux of the entire control method used. For the average New York City winter the vacuum will be around 20 in., which is a steam temperature of 161 deg, and the control valve will be about 30 per cent open. Prompt response to weather changes is an inherent feature of this control, insuring a minimum steam consumption without over- or under-heating.

Each building is a complete heating system in itself, with its own control and vacuum pumps. There are, however, only 14 control rooms for 35 buildings and in order to centralize the heating controls, all control panels are located in these rooms. Each control room therefore operates two or three buildings.

Buildings Not Zoned for Exposure

Zoning of the buildings for exposure was considered but not done. The deciding factor was that the substantial extra cost in splitting up the mains and doubling up the control equipment would not be justified by the savings resulting in steam consumption.

Instead, reliance is placed in the use of the dampers on the convectors. The north-facing rooms must be kept up to temperature and on a sunny day the south-facing rooms will somewhat overheat. By closing the dampers, the tenant can reduce the heating effect by 50 per cent and by using intermediate positions the tenant can to that extent control his own heating.

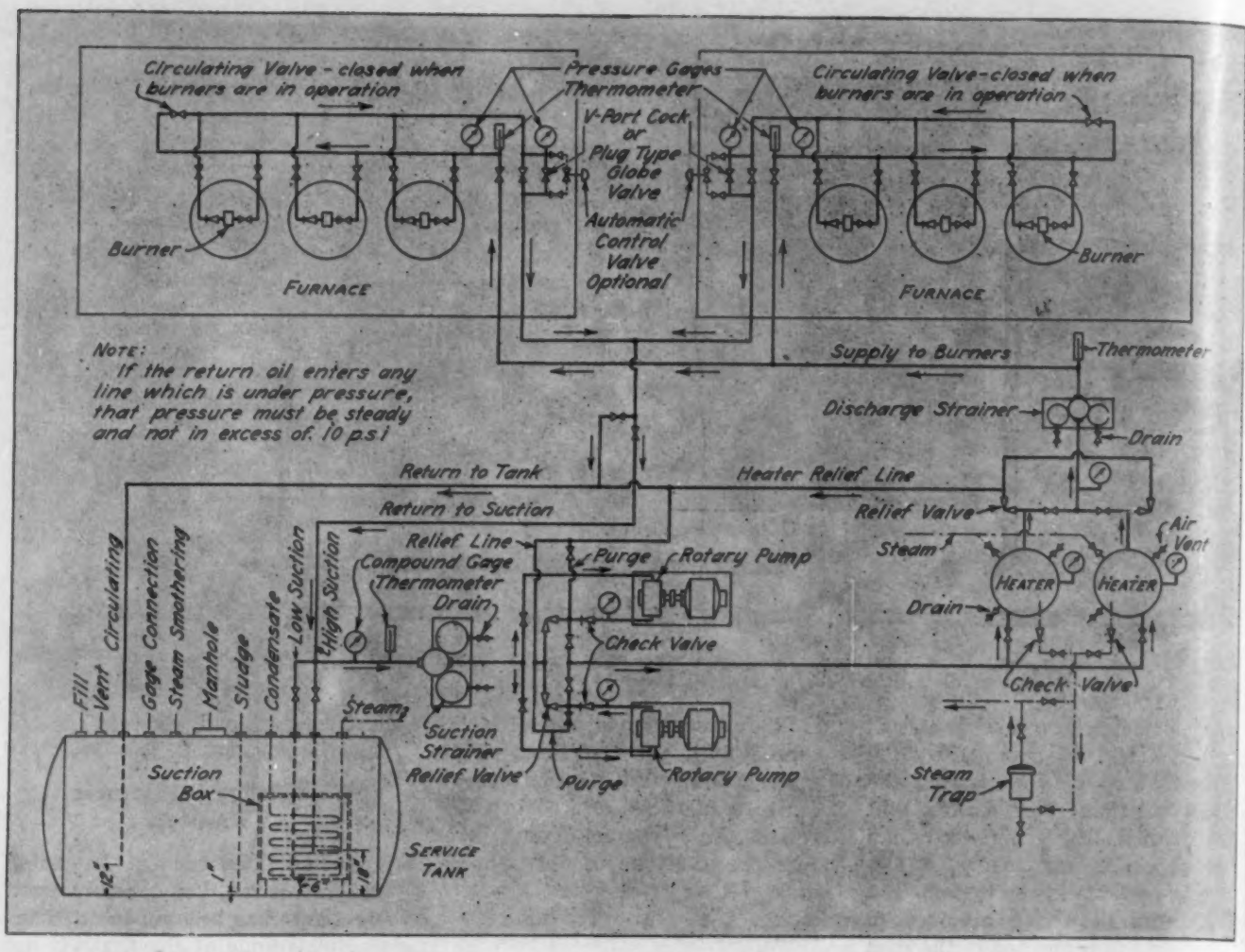
The building walls are 13¾ in. thick, composed of 4 in. brick, 6 in. cinder block, ⅛ in. damp-proofing, 2⅝ in. air space, ⅜ in. reflective gypsum lath, and ⅝ in. plaster. The heat transfer rate is figured at 14.4 Btu per sq ft of wall area based on zero to 70 deg. The total heat loss from the average apartment at Stuyvesant Town is 77.3 sq ft EDR, and 60 per cent of this is in the convectors, the balance being in heat risers and exposed Metro risers.

Wide Range Oil Burners at Riverton

A new advancement in firing moderate sized, low pressure heating plants has been made at Riverton, where one of the first—if not the first—applications of wide-range mechanical atomizing fuel oil burners has been made. Unique in application, the equipment maintains the correct ratio of oil flow and air flow over a wide load range. Such installations had heretofore been confined to large power plants where maximum efficiency is the criterion applied to all equipment to assure economic plant operation. It is anticipated that the fuel oil system used at Riverton will result in an increase in efficiency of 5 to 6 per cent over the conventional type of burner.

Fuel oil burners are the pressure mechanical atomizing type. These burners have no moving parts—only the oil is in motion. Control of the atomizing force across the burner tip is the factor that insures uniform atomization and efficient combustion from the lowest to highest firing rate.

Combustion air is supplied by motor driven forced draft fans at the rear of each boiler. After leaving the fans, the air is forced through hollow tile air lanes under the furnace floor to a windbox



One of the first—if not the first—applications of wide-range mechanical atomizing fuel oil burners has been made at Riverton

mounted on the front of the boiler. Air registers are mounted on the windbox and are designed not only as a means to convey the air to the combustion zone, but to direct it to the critical area with the proper turbulence to assure highly efficient combustion results. The oil atomizers are centrally mounted in the air register hub and complete the burner assembly.

A combustion control system meters the supply of fuel oil and air so that correct proportions of these two elements are maintained. Range of burner operation is accomplished by varying the flow of return oil from the burners. One back pressure regulating valve is used on each boiler to control this function within predetermined limits as impulses are received from the steam header through a master controller which is part of the combustion control system. This master controller is also connected to air flow controllers which, by operating each forced draft fan through a hydraulic power cylinder, meters the supply of combustion air supplied by the fan. Furnace pressure connections measure differential draft loss and, by means of their connection with the master controller, maintain exact air flow to match the oil feed.

When a metering type control system is applied to wide-range, mechanical atomizing burners, steam pressure is accurately maintained within close limits over the full range of burner operation.

Pumping and preheating of the bunker C fuel oil is done by a centrally located fuel oil pumping and heating set comprising a *duplex* arrangement of fuel oil pumps, oil heaters and strainers, as well as all temperature regulators, gages, valves, and other equipment required for carefree and effective operation.

The entire fuel system is schematically shown in an accompanying sketch.

The mechanical design for the three projects was done by Meyer, Strong and Jones, Inc., in cooperation with the board of design set up by the owners. The heating contractor is Baker, Smith & Co., Inc.

SUGGESTS WAY TO BEAT OIL SHORTAGE

It has been roughly estimated, says the Oil-Heat Institute of America, that if the efficiency of the presently installed approximately three million power driven oil burners could be stepped up about 10 per cent at once, there would be no oil transportation shortage problems next winter. The OHI, therefore, recommends an all-out effort to increase efficiency on all existing oil burner installations; to see that all new installations are turned over to users in operating condition that guarantees the highest possible degree of efficiency; and to replace (quickly) all inefficient and wornout installations.

INDUSTRIAL USERS of gas are subject—particularly these days—to complete interruptions of their gas supply on very short notice. Thus, to maintain any sort of a production schedule at all, a large user of gas for heat treating or other industrial purposes needs a standby source of fuel that can be cut in when the utility company gas must be shut off. Such was the situation at the Ingalls-Shepard Div. of Wyman–Gordon Co., Harvey, Ill., so facilities for bulk storage of propane—which is delivered by tank car—and the necessary piping, pressure regulating, and vaporizing facilities were put in last year. An overhead pipe line some 400 ft long, which crosses a state highway, conveys the liquid propane from the storage tanks to the vaporizer house. A description of the installation is given here

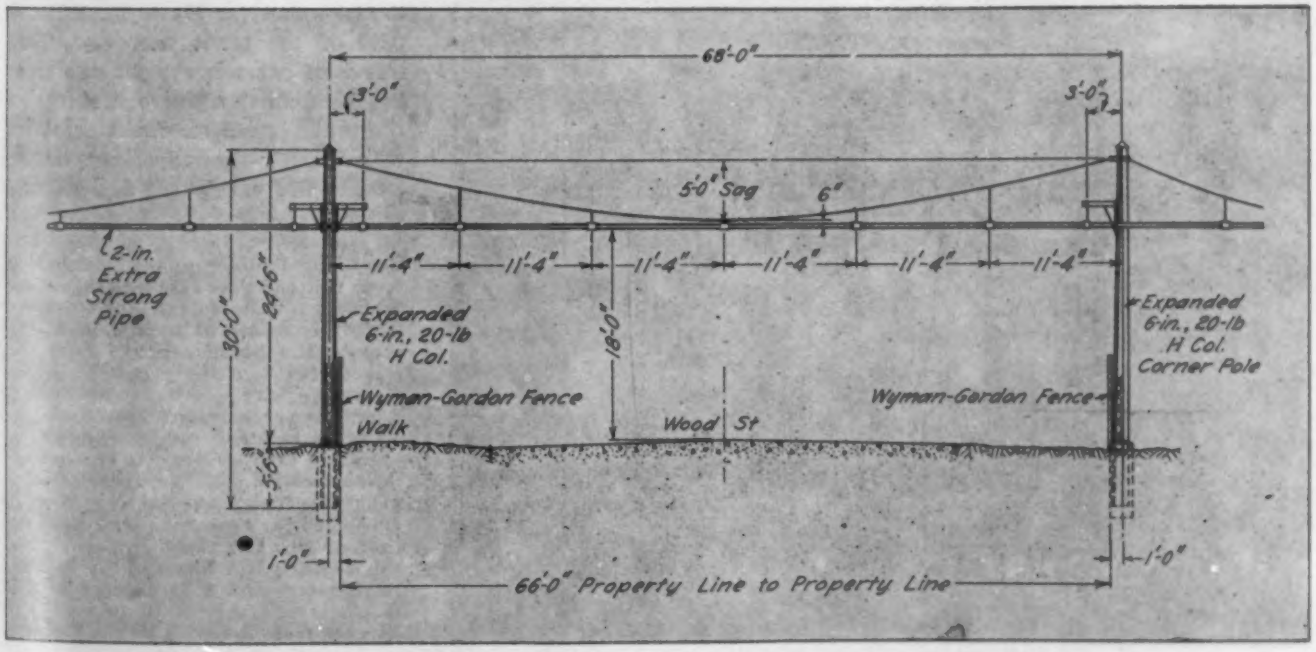
Propane Storage and Piping System Frees Plant from Gas Interruptions

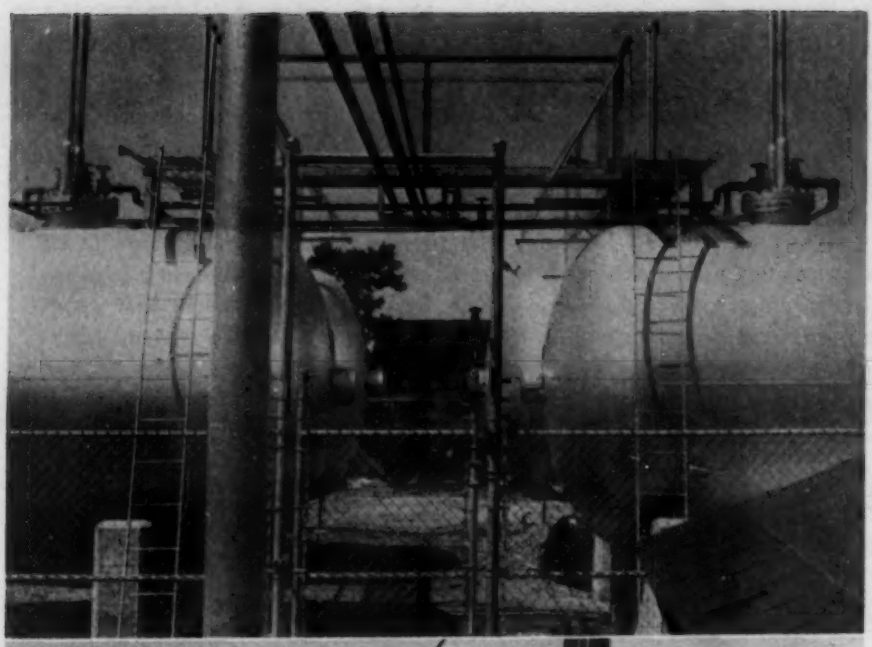
Because of restrictions on the use of gas for heat treat purposes, the Ingalls-Shepard Div. of the Wyman-Gordon Co., Harvey, Ill., manufacturers of drop forgings, installed last year a propane storage, piping, and vaporizing system. When the gas utility company advises Wyman-Gordon that natural gas cannot be used for heat treating, the propane system is put into use. Such occasions arise throughout the year—in winter due primarily to other customers requiring gas for space heating, and in summer because of work being done on the cross-country gas transmission lines, etc. Without the propane installation for heat treat needs, it would be impossible for the plant to operate on any sort of a production schedule. Last winter there were a few anxious days when plant engineers and production men were practically looking down the track awaiting arrival of promised tank car shipments of propane.

The plant is told by the gas utility company how many cubic feet it may use during a 24 hr or some other period. With this information, the use of the propane fuel is planned to the best advantage, allowing of course for production schedules, the relative costs of using propane and the regular gas supply, etc. Were it not for the standby propane installation, complete shutdowns of the heat treat department would be inevitable on many occasions.

An overhead pipe line about 400 ft long that crosses a busy state highway conveys the propane from the bulk storage tanks to a vaporizer house. From the vaporizer house the propane-air mixture is fed into the gas system supplying the heat treat department. Once the propane gas is fed into the regular gas system, it is burned and

An interesting feature of the propane piping is the method used for crossing a state highway, the span being 68 ft





controlled by the same equipment as used for natural gas.

The liquid propane is delivered by railroad tank cars to a siding, this section of track being isolated electrically and well-grounded for protection against lightning and static discharge. The pressure of the partly liquid and partly vaporized propane in the tank cars is sufficient to unload the cars partially through permanent trackside piping to the plant's storage tanks. Vapor is then pumped from the storage tanks back to the tank cars to create a pressure differential to complete the unloading.

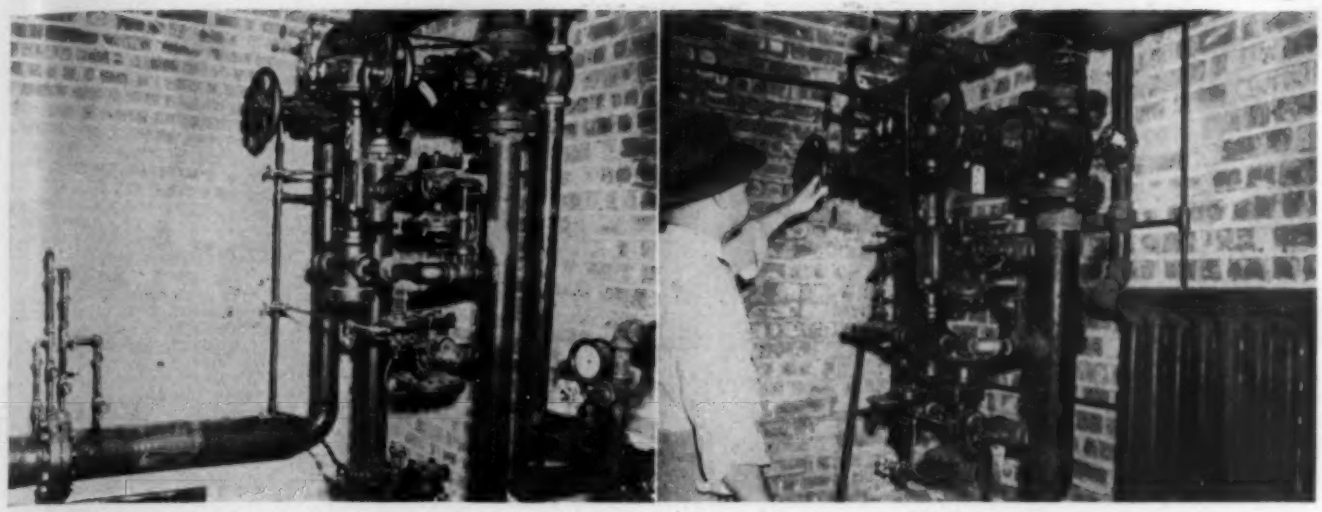
The unloading line from the railroad siding to the storage tanks is 2 in. in diameter, and the vapor line from the tanks back to the siding is of 1 in. diameter. These piping runs are each about 60 ft long.

Four Big Storage Tanks

There are four 30,000 gal horizontal storage tanks, each approximately 65 ft long and 9 ft in diameter, fusion welded of approximately 1 in. plate. Each tank is supported on two concrete saddles and is equipped with pressure and temperature indicators. The tanks are painted aluminum to reflect the sun's heat. The pressure within the tanks varies from around 35 lb per sq in. to 250 lb per sq in., depending on how full they are and the outdoor temperature.

The 400 ft overhead welded pipe line runs from these storage tanks to the vaporizer house on another part of the plant property. This line is of extra heavy ferrous pipe, 2½ in. diameter where it starts at the tanks and 2 in. diameter at its entrance to the vaporizer house. Due to fire safety regulations, the

Top: The liquid propane is unloaded from railroad tank cars into these four 30,000 gal bulk storage tanks. Center: A 400 ft overhead welded pipe line conveys the liquid propane from the storage tanks to the vaporizer house. Because of fire safety requirements, it does not cross over any building. Valves permit isolating sections of the line, and each section has vents to relieve excessive pressure. Bottom: Catenary suspension of the pipe line is employed for crossing a state highway that divides the plant property. For this crossing, the propane line is 2 in. in diameter and it is encased in a 3 in. "sleeve"; this is to prevent any leakage from dripping on the highway



Left: In the vaporizer house, the liquid propane passes through the necessary pressure regulators and is vaporized in a heat exchanger by plant steam passing through the heat exchanger tubes. The vapor is metered by means of an orifice plate installed in the piping. From taps on either side of the orifice plate, connections are made to the ratio controller on the other side of the firewall. This controller maintains a constant ratio of compressed air according to the demand or pull on the propane-air mixture at the furnaces. Right: Compressed air from the plant air line is added to the vaporized propane in the vaporizing house, under the control of a pressure reducer regulator and an air-gas ratio controller. This photo shows the air pressure regulators. The propane is then ready for use by heat treat department

line does not run across any building, but is supported by brackets on outside building walls or by columns for its entire length. There are several isolating valves in the line, and each section of this piping is vented to relieve pressure in the event of a fire anywhere along the line. Flow of the liquid propane through this line is created by the pressure existing in the storage tanks.

Overhead Piping Crosses Highway

An interesting feature of this overhead propane pipe line is the method used for crossing a busy state highway that divides the plant property. The span is 68 ft and the pipe line is 18 ft above the surface of the highway.

Catenary suspension is used for the crossing, with a 30 ft high expanded H column at one end and an expanded H column corner pole at the other (the pipe line angles off about 45 deg after crossing the roadway). The piping is hung from 7/16 in. extra strength cable, which is supported from these columns.

In order that any possible leakage from the propane line will not drip down onto the highway, this portion of the line comprises 2 in. extra heavy pipe encased in 3 in. extra heavy pipe. Tack welds keep the 2 in. pipe concentric inside the 3 in. encasing sleeve; the annular space between the two sizes of pipe is open at each end of the crossing so that if there were any leakage it would drip down onto company property at one end or the other. This section of the line was raised quickly with a tractor-mounted derrick, with minimum interference to traffic.

Propane Vaporized by Steam

After the liquid propane enters the vaporizer house, it passes through pressure regulating valves that reduce its pressure to 30 lb per sq in. It then proceeds to a heat exchanger coil, the tubes of which contain steam from a 1 in. diameter plant steam line. This steam enters the heat exchanger at 10 lb per sq in. pressure through a 1 in. diameter connection. The vaporized propane then passes through a liquid trap to another set of pressure regulating valves which maintain a 20 lb per sq in. pressure of the propane gas.

Compressed air (from a 3 in. diameter plant air line at 100 lb per sq in. pressure) is then added to the propane gas; the air pressure is maintained at 22 lb per sq in. and the propane gas at 20 lb per sq in. for this mixing process. The correct ratio of air to be added to the propane is governed by a proportioning regulator installed on the other side of a separating firewall in the vaporizer house, which proportions the air to the gas.

The propane-air mixture is then ready for use by the heat treat department. It goes to the adjoining gas meter house, where—after metering—it is fed into the regular gas supply line for the heat treat. A valve at this point permits use of either public utility gas or the propane gas, as the case may be.

[Thanks are due F. D. Hurley, chief draftsman, Ingalls-Shepard Div., Wyman-Gordon Co., for courtesies in connection with this description, and to Miss Florence Cross, editor of the company publication *Forging Ahead*, for the photos, which were taken especially for this article.]

AIR CONDITIONING FOR NAVY SHIPS ESSENTIAL

The increased power and destructiveness of modern weapons have made it imperative to seal ships tighter and provide greater cover and protection for personnel, making air conditioning of Navy vessels increasingly important, according to Commodore R. Morgan Watt, Jr., deputy chief of the Navy Department's material division. During a visit to industrial plants engaged in Navy work in the Syracuse area, Commodore Watt told Carrier Corp. officials that mere ventilation is no longer the answer.

"Control of temperature and humidity to afford our men the opportunity to be at their fighting best at all times—even with the ships sealed to insure the greatest degree of personal safety under fire—is of major importance in the modern ship," he said.

Methods of Making PIPING FLEXIBILITY Analyses

By Henry Carlier* . . . Foreword and Translation by Arthur McCutchan†

THE AUTHOR OF this article, a most distinguished Belgian engineer, has greatly influenced the development of more practicable methods of analyzing piping flexibility problems. His first booklet, "L Aptitude Elastique des Tuyauteries a Vapeur au point de vue Dilation," was published in 1925, with a supplement in 1927. A second booklet, "La Tuyauterie de Vapeur, son Aptitude Elastique a Absorber les Effets de la Dilation," published in 1935, is the basis for his present analysis of the two problems considered in this series. The text of Mr. Carlier's manuscript was submitted in French, but he thoughtfully used English units throughout the calculations.

Certain liberties were taken in translating the text such as changing to the impersonal passive voice in order to conform with usual American practice.—ARTHUR MCCUTCHAN.

Lines in One Plane

The theory of flexure of curved pieces was first applied by the author to a certain number of lines in one plane. The lines were limited to two fixed ends.

Equations were used of the form:

$$\Delta x_1 = -\int (y_1 - y)\frac{Mds}{EI} \quad \ldots[1]$$

$$\Delta y_1 = \int (x_1 - x)\frac{Mds}{EI} \quad \ldots\ldots[2]$$

With the condition $\int Mds = 0$ . . [3]

in which x_1 and y_1 were coordinates of a particular point such as the temporarily assumed free end and x and y were coordinates of any point on the line. M, bending moment; ds, elementary length; E, modulus of linear elasticity; I, moment of inertia.

At the International Congress of Liege in 1930, a new method of calculation was presented by the author. The condition [3] was found to permit a rearrangement of equations [1] and [2] in the form:

$$\Delta x = \int \frac{M\,y\,ds}{EI} \quad \ldots\ldots[4]$$

$$\Delta y = \int \frac{M\,x\,ds}{EI} \quad \ldots\ldots[5]$$

In Fig. 1, the coordinates of the center of gravity of the plane figure are designated as n and m; the reacting forces as P and Q acting in the directions given by the X and Y axes, respectively. The resultant of these forces is designed as F:

$$F = \sqrt{P^2 + Q^2}$$

Formula [3] enables the moment at end a to be established as:

$$M_a = Pm - Qn \quad \ldots\ldots[6]$$

At any point (x, y) the bending moment is obtained from:

$$M = -M_a + Py - Qx \quad \ldots.[7]$$

Using equations [6] and [7], equations [4] and [5] become:

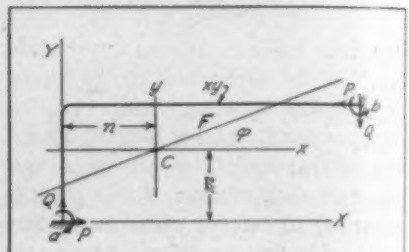


Fig. 1—One plane line

$$\Delta x = \frac{(PI_x - QI_{xy})}{EI} \quad \ldots\ldots[8]$$

$$\Delta y = \frac{(QI_y - PI_{xy})}{EI} \quad \ldots\ldots[9]$$

These formulas are of general application. I_x and I_y are the moments of inertia of the line referred to the axes x and y which pass through the center of gravity of the figure. I_{xy} is the centrifugal moment of inertia referred to the same axes.

In 1935 several notable properties of the central force F (the resultant of the internal forces),

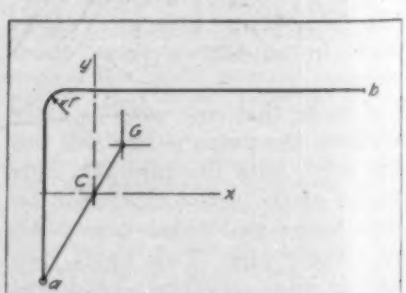


Fig. 2—Projection of line in space

*Ingenieur en Chef Honoraire des Charbonnages de Ressaix, Waudrez (Binche) Hainaut-Belgique.

†Senior Research Engineer, Product Engineering and Research, Tube Turns, Inc.

whose direction is defined by tan $\phi = Q/P$, were revealed by the author. These properties are advantageously used in calculating elastic deformations.

The Karman flexibility factor, K, is used to take into account the extra flexibility of curved portions due to flattening of the pipe cross-section during flexure in the plane in which the bend is located.

Lines in Space

The method of calculations described in connection with lines in one plane has been extended to pipe lines in space. The line is projected on the three planes formed by the axes X, Y, and Z. For the torsional rotation of the branch perpendicular to the plane under consideration, a factor 1.3 is applied to the straight pipe only. (Note: A factor of 1.25 customarily has been used by the author for lines in torsion in former publications.) For bending, each projection of the line is considered as a one plane line.

Referring to Fig. 2, G = center of gravity (α not included), C = center of gravity of the entire line. G, C, and a are located on a line.

THERE ARE numerous methods of analyzing the flexibility of piping systems and a great amount of material on this important subject has been published. In the June 1946 HPAC, Sabin Crocker and Arthur McCutchan reviewed the various methods, and suggested that the advocates of the different schemes each briefly outline the merits of his method and show the solution of two problems; in this way, the reader can judge for himself the suitability of the different calculation procedures in his own piping work. . . . S. W. Spielvogel followed this suggestion in the July 1946 issue, explaining the essentials of the elastic center method, and in September M. J. Fish discussed the graphical method. In November 1946, W. G. Hooper covered the tabular integration method and solved the two problems given by Messrs. Crocker and McCutchan by that means. In the January 1947 number, R. C. DeHart explained the moment distribution method; H. V. Wallstrom reviewed the general analytical method in May; and in August, Lale C. Andrews discussed a model test method.

$$\alpha = \frac{q\mu}{EI}$$

in which α = angle of twist; $q = 1.3(h - r)$; μ = twisting moment; h = dimension perpendicular to plane; r = radius of bend joining line perpendicular to plane.

From which a system of three equations is obtained of the form:

$$P(I_{x1} + I_{x2}) - QI_{x_2 y_2} - R_{x_1 z_1} = EI\Delta_x$$

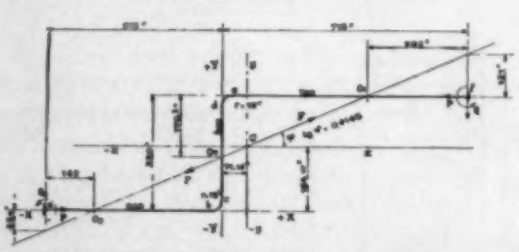
By utilizing the properties of the central force, the calculation of the elastic displacements can be done as for a line in one plane.

The author wishes to emphasize that he does not consider an analysis of piping flexibility complete unless the elastic displacements of the various parts of the line are determined. The greatest importance is attached to the question of hangers or supports for the line.

Sample Problems

The solutions for the two sample problems which follow have been carried through in detail. These solutions afford a good demonstration of the author's methods and show the manner in which the displacement of the various parts of the line can be determined.

Z - BEND WITH WELDING ELBOWS



Temp. range : 60 - 725 F

10.75" OD x 0.393" Wall.

I = 244.8 in⁴ , E = 25,000,000 psi

Δ_X = 1230/12 x 5.88/100 = 6.03 in.

Δ_Y = 330/12 x 5.88/100 = 1.62 in

Flexibility Constant K = 4.7

Modified Length of Quarter Bend = $\frac{\pi}{2} RK$ = 110.68"

Position of Centroid (axes XY)

Member	Length in	Ms/x	Ms/y
ab	500	0	- 132,800
bc	110.68	602.77 *	- 602.77
cd	300	49,900	0
de	110.68	33923.27 **	+ 602.77
ef	700	231,000	+ 255,000
L =	1781.36"	317,026.04	122,800

$m = \frac{317,026.04}{1781.36}$ = 184.17" $n = \frac{122,800}{1781.36}$ = 71.16"

n, m are the coordinates of centroid

* $0.87 r^2 K$ ** $(1.57 \times 315 + 15) 15 \times 4.7$

Line Inertias (XY)

	I_X	I_Y	I_{XY}
ab	0	$\frac{500^3 - 71.16^3}{3}$ = 45,529,167	0
bc	$0.155 \times 15.5^4 \times 4.7$ = 5631	5631	1110 ⊖
cd	$\frac{300^3 - 71.16^3}{3}$ = 10,417,500	0	0
de	0 11,661,306	5631	+ 197,895 ⊕
ef	700×330^2 = 76,230,000	$\frac{771.16^3 - 71.16^3}{3}$ = 121,640,833	+ 84,310,000 ⊕
	I_X = 98,314,527	I_Y = 167,381,262	I_{XY} = 84,511,695

① $(1.57 \times \sqrt{315}^2 + 2 \times 315 \times 15 + 0.785 \times 15^2) 15 \times 4.7$

② $[-(0.87 \times 15) + (15 - \frac{15}{2})] 15^2 \times 4.7$

③ $[(1.57 \times 315 + 15) - (315 + \frac{15}{2})] 15^2 \times 4.7$

④ $700 \times 365 \times 330$

Line Inertias (x,y)

I_x	I_y	I_{xy}
I_x = 98,314,527	I_y = 167,381,262	I_{xy} = 84,511,695
$-Lm^2$ = -58,386,686	$-Ln^2$ = - 8,717,100	$-Lmn$ = - 22,560,825
I_x = 39,927,841	I_y = 158,664,162	I_{xy} = 61,950,870

P and Q are the reacting forces at the ends, following the directions X and Y.

The equations are:

$$\frac{1}{EI}(39,927,841P - 61,950,870Q) = \frac{1230}{12} \times \frac{5.88}{100} = 6.03 \quad . \quad (1)$$

$$\frac{1}{EI}(158,664,162Q - 61,950,870P) = \frac{330}{12} \times \frac{5.88}{100} = 1.62 \quad . \quad (2)$$

Dividing these equations member by member and re-arranging, they reduce to

$$39.93P - 61.95Q = 123$$

$$-61.95P + 158.66Q = 33$$

Solving these simultaneous equations: $P = 8.67$ and $Q = 3.59$

$$\frac{Q}{P} = \frac{3.59}{8.67} = \tan\theta = 0.4145$$

θ = the inclination of the central force F to the X axis

The points Q_1, Q_2 and Q_3 are the points of inflection, or zero bending moment in the line. With $Q = 0.4145P$, the first equation becomes:

$$\frac{1}{EI}(14,249,206P) = 6.03 \text{ or}$$

$$2,363,000P = EI \quad \ldots\ldots (3)$$

$$P = \frac{58,000,000 \times 244.8}{2,363,000} = 2590 \text{ lb}$$

$$Q = 0.4145 \times 2590 = 1074 \text{ lb}$$

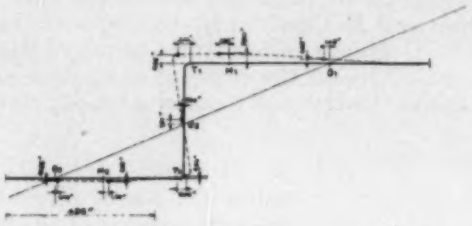
$$M(f) = 121P \qquad M(a) = 58.9P$$

$$M(\text{elbow bc}) = 155F = 155\sqrt{1 + 0.4143^2}P = 167.7P$$

Stress in middle wall of lower elbow:

$$S = \frac{Mc}{I} = \frac{167.7 \times 2,590 \times 5}{244.8} = 8,870 \text{ psi}$$

Points	Thermal Displacements		Elastic Displacements		Resultant Displacements	
	X	Y	X	Y	X	Y
O_1	1.43" ←			1.45" ↑	1.43" ←	1.45" ↑
M_1	2.86" ←			2.90" ↑	2.86" ←	2.90" ↑
T_1	3.43" ←			2.52" ↑	3.43" ←	2.52" ↑
O_2	3.80" ←	0.86" ↓	3.10" →	2.37" ↑	0.34" ←	1.51" ↑
T_2	2.45" →			0.54" ↑	2.45" →	0.54" ↑
M_2	1.40" →			0.33" ↓	1.40" →	0.33" ↓
O_3	0.70" →			0.166" ↓	0.70" →	0.166" ↓



Elastic Displacements $\frac{2\,363\,000\,P}{EI} = 1$ (3)

$O_1 : f_{O_1} = \frac{\overline{580}^3 Q}{EI} = \frac{3439781\,P}{EI} = \frac{3439781}{2363000} = 1.45"$ ↑

$M_1 : f_{M_1} = 2 \cdot 1.45 = 2.90"$ ↑

$T_1 : f_{T_1} = \frac{(3 \cdot 292 - 700)\,\overline{700}^2 Q}{EI} = \frac{5953168\,P}{EI} = \frac{5953168}{2363000} = 2.52"$ ↑

$O_2 :$ $I_x(o_2) = 26078747$, $I_y(o_2) = 121846484$, $I_{xy}(o_2) = 44893705$

$\Delta x(o_2) = \frac{26078747\,P}{EI} - \frac{44893705\,Q}{EI} = \frac{8471307\,P}{EI} = \frac{8471307}{2363000} = 3.16"$ →

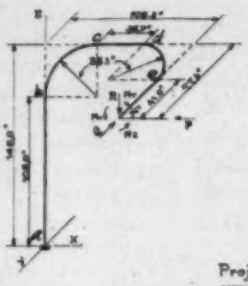
$\Delta y(o_2) = \frac{121846484\,Q}{EI} - \frac{44893705\,P}{EI} = \frac{56111644\,P}{EI} = \frac{56111644}{2363000} = 2.37"$ ↑

$T_2 : f_{T_2} = \frac{(3 \cdot 148 - 500)\,\overline{500}^2 Q}{EI} = -\frac{1276378\,P}{EI} = -\frac{1276378}{2363000} = -0.54"$ ↑

$M_2 : f_{M_2} = 2 \cdot f_{O_2} = 0.33"$ ↓

$O_3 : f_{O_3} = \frac{142^3 Q}{EI} = \frac{395602\,P}{EI} = \frac{395602}{2363000} = 0.166"$ ↓

Three dimensional pipe bend



Temp. range : 0 - 650 F

2.286" = 0.241" wall

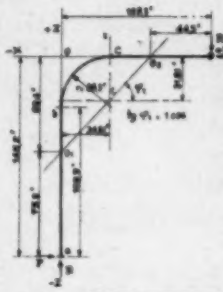
$I = 33.14$ in^4

$E = 24000000$

$\Delta x = 0.86"$, $\Delta y = 0.47"$, $\Delta z = 0.88"$

flexibility constant $K = 2.29$

Projection XZ



Position of centroid

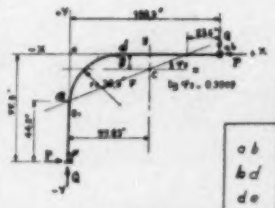
	L'	Ms/x	Ms/z
ab	109.9	$\frac{146.2^2 - 36.3^2}{2} = 9660.87$	—— 0 ——
bc	130.6	$0.57 \cdot 36.3^2 \cdot 2.29 = 1719.98$	1719.98
cd	72.0	—— 0 ——	$\frac{108.3^2 - 36.3^2}{2} = 5001.60$
ef	53.3	—— 0 ——	$53.3 \cdot 108.3 = 5772.39$
L.	364.9	Ms/x = −11602.55	Ms/z = 12697.97
		$m = \frac{-11602.55}{364.9} = -31.8°$	$n = \frac{12697.97}{364.9} = 34.8°$

Line Inertias

	Ix	Iz	Ixz
ab	$\frac{146.2^3 - 36.3^3}{3} = 1004478.08$	—— 0 ——	—— 0 ——
bc	$0.365 \cdot 36.3^4 \cdot 2.29 = 3988514$	39885.14	$-0.29 \cdot 36.3^3 \cdot 2.29 = -7667.49$
cd	—— 0 ——	$\frac{108.3^3 - 36.3^3}{3} = 407468.00$	—— 0 ——
ef	—— 0 ——	$53.3 \cdot 108.3^2 = 625149.33$	—— 0 ——
	Ix = 1043380.32	Iz = 1071503.85	Ixz = −7667.49
	① $-Sm^2 = 369050.29$	② $-Sn^2 = -442015.33$	③ $-S(-m)n = +403302.42$
	Ix = 674330.	Iy = 629488	Ixz = 395635

① $Sm^2 = 11602.55 \cdot 31.81$ ② $Sn^2 = 12697.97 \cdot 34.81$ ③ $12697.97 \cdot 31.81$

Projection XY



Position of centroid

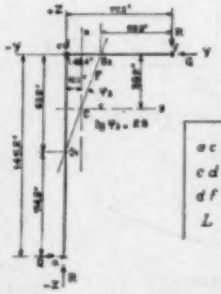
	L'	Ms/x	Ms/y
ab	141.97	—— 0 ——	$141.97 \cdot 109.3 = 15332.03$
bd	72.0	—— 0 ——	$\frac{109.3^2 - 36.3^2}{3} = 3215.60$
de	130.5	1719.98	1719.98
ef	41.0	$\frac{77.3^2 - 36.3^2}{3} = 2328.90$	—— 0 ——
L.	385.47	Ms/x = −4048.78	Ms/y = 22267.61
		$m = \frac{-4048.78}{385.47} = -10.5°$	$n = \frac{22267.61}{385.47} = 57.83°$

Line inertias

	Ix	Iy	Ixy
ab	—— 0 ——	$141.97 \cdot 109.3^3 = 16604538$	—— 0 ——
bd	—— 0 ——	$\frac{109.3^3 - 36.3^3}{3} = 407468.00$	—— 0 ——
de	39885.14	39885.14	−7667.49
ef	$\frac{77.3^3 - 36.3^3}{3} = 138019.00$	—— 0 ——	—— 0 ——
	Ix = 177904.34	Iy = 2108612.97	Ixy = −7667.49
	① $-Lm^2 = -42491.78$	② $-Ln^2 = -1887715.46$	③ $-Smn = +234025.28$
	Ix = 135413	Iy = 819077	Ixy = +226357

$Lm^2 = -4048.78 \cdot (-10.5)$ $Ln^2 = 22267.61 \cdot 57.83$ $Smn = -4048.78 \cdot (-57.83)$

Projection YZ



Position of centroid

	L'	Ms/y	Ms/z
ac	148.2	$-\frac{146.2^2}{2} = -10541.52$	—— 0 ——
cd	46.4	—— 0 ——	—— 0 ——
df	77.3	—— 0 ——	$\frac{77.3^3}{3} = 2987.6$
L	268.9	Ms/y = −10541.52	Ms/z = 2987.6
		$m = \frac{-10541.52}{268.9} = -39.2°$	$n = \frac{2987.6}{268.9} = 11.1°$

Line inertias

	Iy	Iz	Iyz
ac	$\frac{146.2^3}{3} = 1220419.13$	—— 0 ——	—— 0 ——
cd	—— 0 ——	—— 0 ——	—— 0 ——
df	—— 0 ——	$\frac{77.3^3}{3} = 153963.3$	—— 0 ——
	Iy = 1220419.13	Iz = 153963.3	Iyz = 0
	$-Lm^2 = -413287.98$	$-Ln^2 = -33162.3$	$-L(-m)n = +117114$
	Iy = 807191.55	Ix = 120801	Iyz = +117114

$Lm^2 = 10541.52 \cdot 39.2$ $Ln^2 = 2987.6 \cdot 11.1$ $L(-m)n = 2987.6 \cdot 39.2$

Projection	P (X)	Q (Y)	R (Z)
XZ	674.280 P - 396.535 R		629.466 R - 396.535 P
XY	134.413 P - 226.357 Q	819.077 Q - 226.357 P	
YZ		607.191 Q - 117.114 R	129.801 R - 117.114 Q

Sum (X) : 808.693 P - 226.357 Q - 396.535 R = ÷ 0.66"
Sum (Y) : 1426.268 Q - 226.357 P - 117.114 R = ÷ 0.47"
Sum (Z) : 750.289 R - 396.535 P - 117.114 Q = ÷ 0.99"

Q = 0.3909 P , R = 1.096 P , R = 2.8 Q

tg φ_1 = 1.090 tg φ_2 = 0.3909 , tg φ_3 = 2.8

The first equation gives:

$$\frac{1}{EI}(808.693\,P - 226.357\,Q - 396.535\,R) = \frac{295.915\,P}{EI} \cdot 0.66$$

or $\frac{433.203\,P}{EI} = 1$

$P = \frac{24\,000\,000 \times 33.14}{433.203} = 1836^{\#}$

$Q = 1836 \times 0.3909 = 718^{\#}$

$R = 1836 \times 1.096 = 1958^{\#}$

Reacting Moments at "a".

XZ-plane Mf = 76.2 P
YZ-plane Mf = 74.9 Q - 29.28 P
$= \sqrt{75.6^2 + 29.28^2}\,P = 77.6\,P = 142,474$ in lbs (bending)
XY-plane Mt = 23.6 Q - 9.23 P = 16,945 in lbs (torsion)

Reacting Moments at "f".

XZ-plane Mt = 44.2 R - 48.77 P = 69,842 in lbs (torsion)
XY-plane Mf = 44.2 P
YZ-plane Mf = 52.2 R - 57.2 P
$= \sqrt{44.2^2 + 57.2^2}\,P = 71.6\,P = 131,458$ in lbs (bending)

Sketch of deformed line

Conditions $\frac{295.915\,P}{EI} = 0.66"$

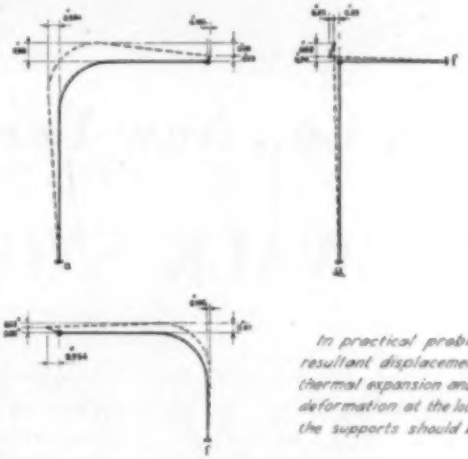
Q = 0.3909 P R = 1.096 P R = 2.8 Q

Elastic displacements along the three directions X, Y, and Z

1" { XZ : 674.280 P - 396.255 R = 930.089 P = 0.634
XY : 134.413 P - 226.357 Q = 45.930 P = 0.106
0.740

2" Y { XY : 819.077 Q - 226.357 P = 93.820 P = 0.22
YZ : 607.191 Q - 117.114 R = 108.994 P = 0.25
0.47

3" Z { XZ 629.466 R - 396.255 P = 293.663 P = 0.68
YZ 120.801 R - 117.114 Q = 86.618 P = 0.20
0.88



In practical problems the resultant displacements from thermal expansion and elastic deformation at the location of the supports should be found

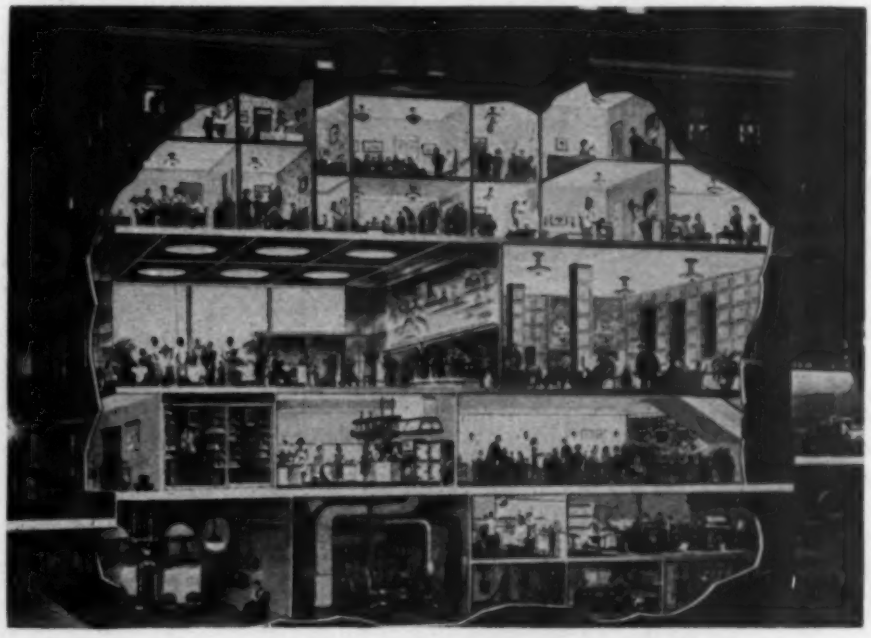
Heat and Cold Are Hotel's "Lifeblood"

The complex and highly mechanized operation of a modern hotel was explained and illustrated in a recently published full page color advertisement prepared by the building materials division of the Armstrong Cork Co. in collaboration with the American Hotel Association. It was the first of a series planned to illustrate and explain the importance of industrial insulation in various fields.

The presentation gives the reader a better understanding of the problems involved in operating a hotel and points out what is necessary to provide many of the "taken for granted" services. For example, the copy of the advertisement reads in part:

"When you look behind the scenes, a modern hotel is an astounding place. Few guests appreciate that their comfort demands such a complex and highly mechanized institution. The men who ordered ice probably don't know that there's a complete ice making plant hidden away in the basement. The dancers in the ballroom don't stop to think what it takes to provide air conditioning. Touch a spigot and ice water spurts out. Turn a valve and heat is waiting. Heat and cold flow through the hotel like lifeblood in its veins."

Cutaway view of hotel shows heating and air conditioning



Best & Co., New York, Installs

SIDEWALK SNOW MELTING SYSTEM

DESIGN OF THE snow removal system for the Best & Co. specialty apparel store sidewalks on 51st St., Fifth Ave., and 52nd St., New York City, was based on the principle of circulating a mixture of hot water and antifreeze through a series of coils imbedded in the sidewalk.

A serpentine system—wherein each coil is primarily a single pipe, bent back and forth upon itself, so that any water pumped into one end would of necessity have to pass through the entire length to get out of the system at the other end—was first considered. However, it was found necessary to design a system so as to eliminate the possibility of any airbinding, permit adequate drainage, and to avoid the necessity of having to take special precautions at the expansion joints in the sidewalk. On this basis, the header system was found to be the best solution for this type of water circulation under these conditions.

The length of piping in each circuit varies, depending on the spacing of the sidewalk expansion joints. Wherever an expansion joint occurs, a separate system of supply and return headers is installed, each one having a 2½ in. supply and a 2½ in. return. All coils are 1¼ in. pipe on 18 in. centers.

The piping is reverse return to insure complete circulation of water through all parts of the system. Water is pumped into a manifold from which a number of circulating pipes emerge. All friction is equalized in this design—for if it is not, there is danger that water pumped into one end of the header would pass through the nearest pipes and not circulate at all (at best, only slightly) in the farthest pipes connected to the header.

To eliminate this possibility, the design definitely called for a reverse return, which puts the water into the far end of one header and extracts it from the near end of the return header, causing equal flow through all of the circulating tubes emerging from the header.

The hot water is obtained from hot water converters heated by steam. This system is operated by manual switches—one key operated, located in one of the vestibules, and one in the chief engineer's office—either of which can start the water circulating pump and simultaneously open the steam valve to the hot water converters.

HARRY H. BOND, of the consulting engineering office of Edward E. Ashley, describes here details of the new sidewalk snow melting system for Best & Co. on New York's Fifth Ave. A header piping system with reverse return to assure good circulation of the water and antifreeze solution was employed. The mixture is heated by converters

The piping is of wrought iron with welding fittings. The pipe loops were fabricated with welding fittings, and eccentric reducers were used where pipe sizes were changed to eliminate air pockets. The piping was laid parallel to the finished slope of the sidewalk. The sidewalk pitches 6 in. from building to curb line.

A steel expansion tank was provided, and a water column was installed on the tank to indicate the level of the liquid within it. It is so arranged that all air is vented from the system.

The circulating pumps are capable of handling 150 deg liquid without airbinding or corrosion, and these are equipped with stuffing boxes which are tight when pumping a mixture of the antifreeze and water. The mixture is proportioned so that the freezing point of the solution will be minus 20 F.

Before the pipes were concealed in the sidewalk, the system was tested to a hydrostatic pressure of 125 psi, and an operating test was performed to demonstrate that the system had been properly balanced and that there was a free and equal

flow of water to all portions of the system, as well as a uniform heat loss throughout the entire system.

All piping within the building was insulated, and the insulation was carried up to a point where the lines entered the sidewalk construction.

In the early part of this year, before the owners moved into the building, New York experienced three snowstorms. The snow removal equipment was put into service, and as the newspaper photographs clearly show, the installation was a great success. Needless to say, the vestibules will not become as wet and sloppy with this snow melting installation, thus reducing maintenance in the cleaning of the store and floors in the winter.

The architects were Shreve, Lamb and Harmon; the builders were John Lowry, Inc.; the electrical and mechanical engineering was designed by Edward E. Ashley, consulting engineer; and the installation of the snow removal equipment was made by Alvord and Swift.

How to Weld LEAD PIPE

Practical information on welding lead pipe used in industrial systems is given briefly here by L. S. Bowser, Linde Air Products Co.

WELDED LEAD PIPING systems are fabricated by following the same general methods of layout used for piping systems of welded steel. Standard lead pipe and fittings are obtainable in a variety of sizes and weights. Special fittings for almost any condition can be made by cutting sheet to size, shaping ("bossing" or "dressing") it on wood or metal forms, and then welding the longitudinal seams. Holes for branch connections are usually melted through the pipe wall with the blowpipe flame. Melted edges are then properly shaped and scraped clean before welding. Because the metal is soft, fitting is relatively easy.

Flanged joints are extensively used. Many chemical and paper plants make their own flanges. Such flanges may be cut from lead sheet to slip over the outside of the pipe. A bevel on the inside edge of the ring (Fig. 1) makes it easy to weld it to the end of the pipe.

The butt type weld is most suit-

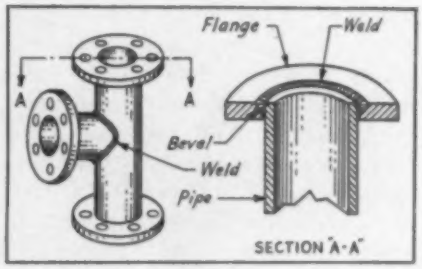
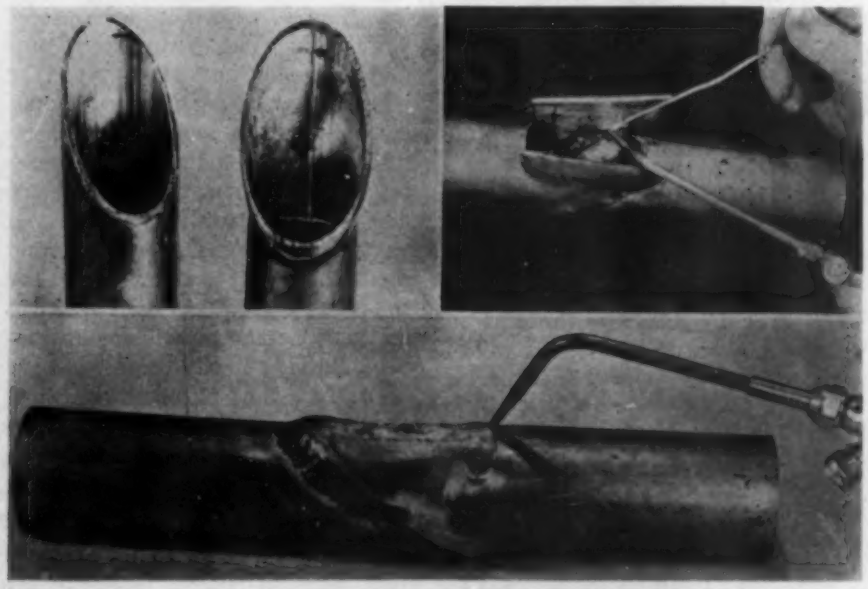


Fig. 1—Special fittings are easily fabricated by welding. Flanges, bevelled on the inside diameter, are cut to slip over the outside of the pipe



Left: Fig. 2—The cup-type joint is widely used in vertical pipe sections because the flared edge of the lower section provides a flat or pocketed surface on which to work. Welding technique is the same as for making a horizontal lap weld in vertical plate. Right: Fig. 3—The split lap joint is used to avoid overhead welding in position. *(a)* The pipe is prepared by cutting at an angle, then flaring and tee-slotting the female end. After the ends have been fitted *(b)*, the upper section is bent outward and the weld is started at the bottom. When the inside weld has been completed *(c)*, the flaps are bent back and the upper section of the joint is completed from the outside

able for any joint that can be rolled horizontally during welding. Edges are bevelled and cleaned the same as for heavy sheet. The pipe is rotated so that all welding can be done in the flat position. Like heavy sheet, relatively thick pipe is welded in a number of passes. With pipe, however, experienced operators find it possible to maintain the rod in the puddle at all times, using a technique very similar to that for welding steel pipe. Operators with limited experience obtain best results by the slower method of adding the molten rod metal a drop at a time.

When the pipe cannot be rotated during welding, abutting surfaces are sometimes flanged. Welding is then handled in the same fashion as the flange weld.

For vertical pipe, the cup joint (Fig. 2) is simplest to weld because the edge of the lower section provides a flat or pocketed surface on which to work. Overlap for such joints should be at least three times the thickness of the pipe wall. The surfaces should be clean. Welding technique is the same as that used for a horizontal lap weld in vertical plate.

To avoid overhead welding in position, the split lap joint (Fig. 3) is sometimes used. The two edges to be joined are cut at an angle and cleaned. The female end is then flared and tee slotted (Fig. 3a). After the pipe has been fitted together, the edges are bent out and the weld is started at the bottom on the inside and continued up the sides as shown in Fig. 3b. When the bottom half of the joint has been made, the flaps are bent back into their original position, welded in place, and the upper half of the joint is completed from the outside (Fig. 3c). In this way the entire weld is made in the convenient flat position.

Don't Overlook Safety Precautions

Because fumes generated during lead welding may be toxic if inhaled in high concentrations or for long periods of time, lead welding operations should be conducted in well ventilated locations. For bench work in an open shop, general ventilation such as an exhaust fan will usually be sufficient. Men working in an open tank should be provided with a positive air supply by a fan or blower directed into the enclosure. When work must be done in a confined space, such as a closed tank or pressure vessel, each man should be required to wear an air supplied respirator or mask.

ELECTED TO HEAD STEEL PIPE GROUP

E. A. Buxton has been elected chairman of the committee on steel pipe research of the American Iron and Steel Institute. He succeeds E. P. Corey, who has retired after 52 years in the steel pipe industry, and who served as chairman of the committee from its inception in 1942.

Mr. Corey has been general manager of tubular sales for the Youngstown Sheet and Tube Co. Mr. Buxton is sales manager, pipe and tubes, for the Bethlehem Steel Co. Oscar I. Strickland, manager of tubular sales for the Wheeling Steel Corp., was elected vice chairman of the committee.

Included in the committee's collection and correlation of technical and commercial data has been the assembling of extensive information on water supplies, which has been published in booklet form. Another booklet by the committee, on Pipe in American Life, recounts the history of the making of pipe and discusses its uses throughout the country.

The committee is working to promote the use of steel pipe for plumbing and heating in homes, large buildings, and industrial establishments; industrial processing; refrigeration; the development and use of natural resources; and on the farm. The average annual production of pipe and tubes for the last six years has been over 5½ million tons and of this amount approximately 2 million tons have been for the purposes outlined above.

The committee is studying the trend and use of corrective water treatment for corrosion and scale prevention; the effectiveness of new chemicals that are advanced for that purpose; the value of temperature control; methods of cathodic protection; new and improved coatings; and new designs of pipe joints and fittings.

HOW TO GUARD AGAINST VENTILATION FAILURES

Ventilating equipment provides basic protection from health and fire hazards in the solvent department and should be inspected regularly. Even well-designed ventilating systems will become inefficient unless properly maintained. To eliminate the five most common causes of failure of ventilating equipment, the following points should be checked, says the Safety Research Institute:

Is the fan running backwards? Strangely enough, this is the most frequent reason for failure of correctly designed equipment. Sometimes a fan requires repairs, and then is reversed when it is started up again. A regular check on the direction of fan motion is important.

Is the fan belt loose? Loose belts cause the fan to run too slowly. Since new belts generally loosen up somewhat after use, they should be adjusted after installation.

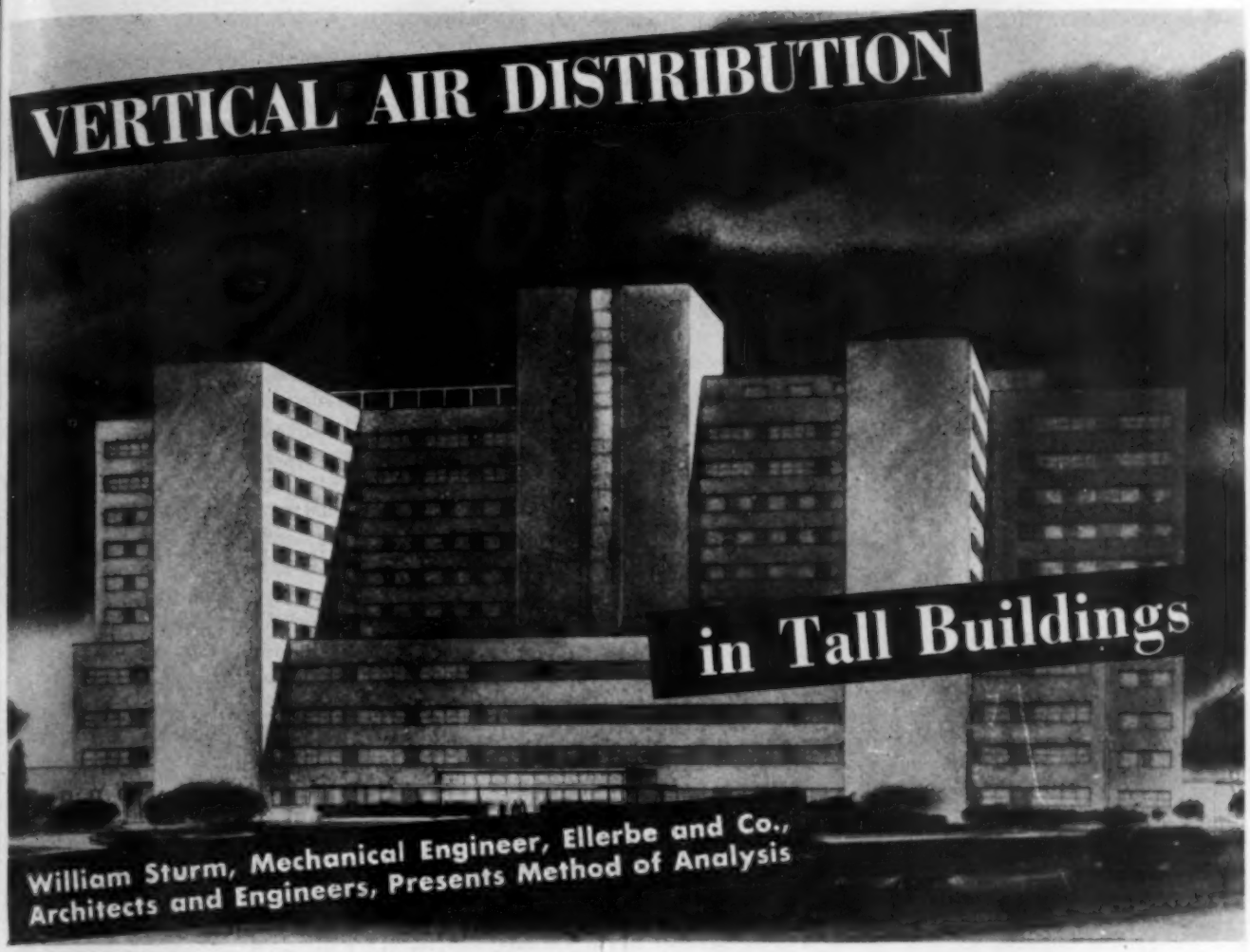
Is the system overloaded? While a system may be correctly designed for the initial load, it often happens that additional outlets are later added, reducing the overall efficiency of the equipment. The velocity of the air stream should be measured regularly and whenever additional ducts are added.

Are the ducts and blades dirty? Dirt in a ventilating system is a frequent cause of breakdown and inefficient operation. Systems should be cleaned regularly. Fans should be run for a few minutes after operations are finished to allow for complete emptying of the ducts.

Is there insufficient make-up air? Since ventilating equipment exhausts air, it cannot run efficiently unless there is provision made for enough make-up air to enter the room.

YOU ARE INVITED TO CONTRIBUTE YOUR VIEWS—HPAC's readers are invited to contribute their views on published articles and other matters to the "Open for Discussion" department, which appears each month (page 120 of this issue). Answers to published questions are welcomed for use in our regular Question of the Month columns (pages 113-114 in this issue).

VERTICAL AIR DISTRIBUTION in Tall Buildings



William Sturm, Mechanical Engineer, Ellerbe and Co., Architects and Engineers, Presents Method of Analysis

BEFORE WE RECOMMEND a solution to the problem of vertical air distribution in a nine story building under winter conditions (as described in the first part of this article in the June HPAC), let us consider a system of supply on a similar basis with which we ventilate at room temperature in the winter and air condition with, say, 55 F air in the summer. First assume that in normal design we would have a positive pressure difference from duct to rooms of 0.04 in. represented by line *K-L*, on Fig. 1, 0.04 in. greater pressure than *C-D* for the winter time ventilation condition.

Next we must construct the summer time condition chart. Line *A-M*, Fig. 2, represents a column of outdoor air at 95 F, again starting with an atmospheric pressure of 394.0 in. at the grade, and subtracting 1.623 in. of water to give a resultant pressure of 392.377 in. at the top of the building, indicated by point *M*. Again we show the corresponding indoor condition for the summer time and take one-half of the difference between the weights of the air columns at 95 F and 80 F, and add half to the outdoor condition at the base of the building, assuming exfiltration at the base in the summer. The other half is subtracted from the outdoor condition at the top of the building. This would be $(1.675 - 1.623) \div 2 = 0.026$ in. and is represented by line *N-O*. We would again assume that one-third of the temperature difference head is available for pressure difference head, and this is indicated by line *P-R*. Line *P-R* is a reference line for inside pressures.

We must next represent a 55 F column of air, which is the supply temperature of our particular air conditioning system. This is represented by subtracting the weight of an 80 F, 40 per cent column, 1.675 in., from a 55 F, 90 per cent relative humidity column, 1.758 in. $= 0.083$ in. and adding one-half of this difference, practically 0.04, to point *O* at the base of the building and subtracting one-half from point *W* at the top. This column of 55 F, 90 per cent relative humidity air is

IN A VERTICAL duct system, air deliveries will be erratic (even to the extent of being in the wrong direction) where the pressure differences between the ducts and the spaces being served are small compared to the pressure differences caused by stack effect of the building. In concluding his discussion of this subject from the June HPAC, the author analyzes the problem under summer conditions and suggests a solution. . . . Mr. Sturm, a graduate of the University of Minnesota, is mechanical engineer for Ellerbe and Co., architects and engineers, and this article was prepared for publication with the assistance of John Dawson, the firm's chief engineer

now represented by line *S-T* on Fig. 2, and to indicate this same 55 F air in the duct system under pressure, we would add 0.04 in. pressure to line *S-T* shown by line *N-U* parallel to line *S-T*.

We are now in a position to determine what the respective air deliveries to the various floors will be for summer, as well as the wintertime conditions. Since the takeoffs from our vertical trunk ducts would be somewhere near the 7 ft 6 in. line for any floor, we can determine the pressure differences at the 9th and 1st floor takeoffs at this 7 ft 6 in. level. These pressure differences are represented by the distance between lines *F-E* and *L-K* for –10 F winter on Fig. 1 and *P-R* and *N-U* for 95 F summer shown on Fig. 2. The winter time pressure difference at the 9th floor is about +0.1 in. and at the 1st floor, about –0.016 in. Summer pressure difference at 9th floor is about –0.004, at first floor about +0.082 in.

Calculating Air Volume

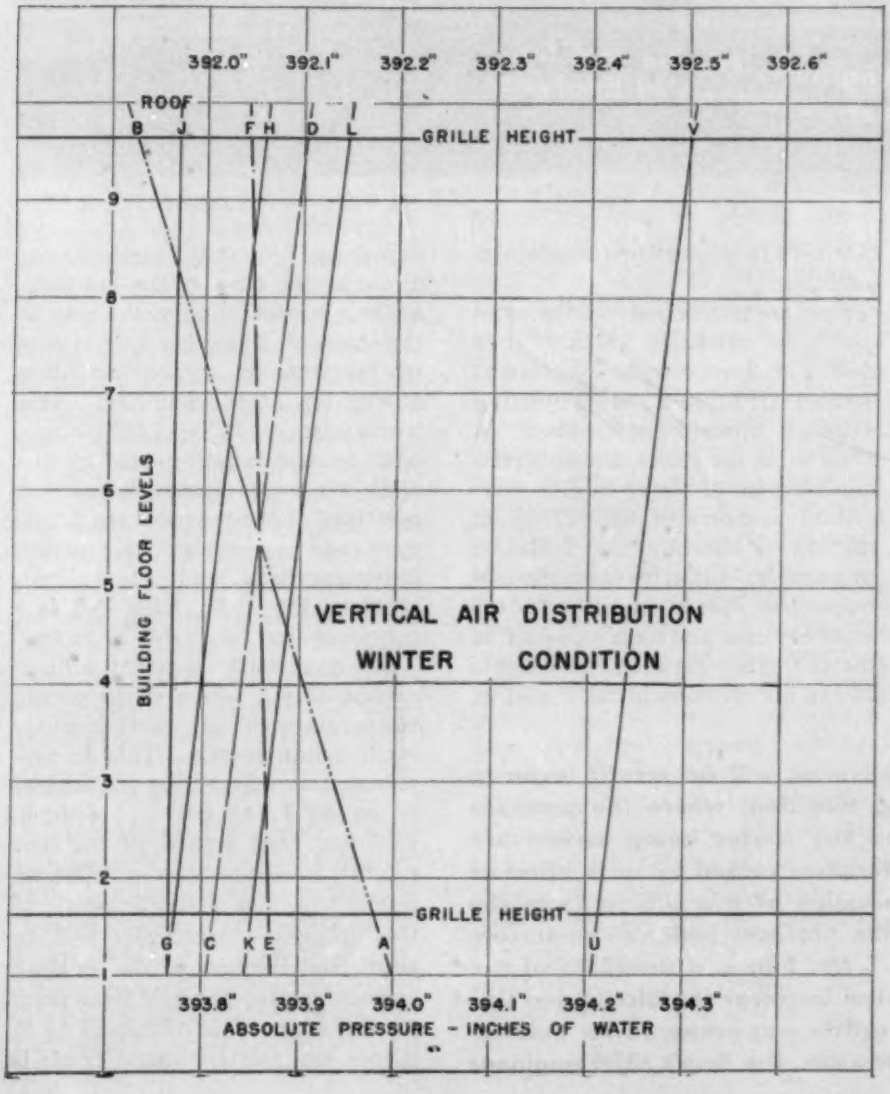
For these pressure differences we can calculate the volumes for equal sized openings, assuming 200 cfm supply for a 0.04 in. pressure difference which occurs at the 5th floor both summer and winter.

The following volumes are calculated by using the formula $V_2/V_1 = \sqrt{pd_2/pd_1}$, where V = volume and pd = pressure difference. For the winter condition at the 9th floor we would have:

$$\frac{V_2}{200} = \sqrt{\frac{+0.1}{+.04}} = \frac{200 \times 0.316}{0.2}$$

$$= +316 \text{ cfm}$$

Fig. 1—Pressures at various points in nine story building under winter conditions



Winter, 9th floor, pd + 0.1 in. = + 316 cfm
Winter, 1st floor, pd — 0.016 in. = — 126 cfm
Summer, 9th floor, pd — 0.004 in. = — 63 cfm
Summer, 1st floor, pd + 0.082 in. = + 286 cfm

During the winter condition at the first floor and the summer condition at the ninth floor, air is actually being exhausted instead of supplied as was intended.

From the above calculations we can see that the system is anything but balanced, and pity the poor operating engineer who endeavors to balance it for year around operation for he would be confronted with no end of difficulties.

How to Balance System

The charts which we have drawn to illustrate our problem have thus far indicated only that a vertical system apparently will not function properly if normal duct design and resistances are used. However, with the use of this chart we can visualize an answer.

Further study of these charts reveals that if a greater than normal pressure drop is assumed at each horizontal takeoff, more nearly equal volumes will result from top to bottom levels. For instance, if we assume a pressure drop of 0.4 in. across horizontal takeoffs instead of the 0.04 in. that we have previously worked with, we draw the lines *U-V* on Fig. 1 for the winter condition, and *W-X* on Fig. 2 for the summer condition. These lines are parallel to and 0.4 in. greater pressure on the chart than the lines *C-D* and *S-T*, respectively.

The actual pressure differences between the building and ducts for these conditions are represented by the distances between lines *F-E* and *U-V* on Fig. 1 for the winter temperatures and *P-R* and *W-X* on Fig. 2 for summer temperatures. Winter time pressure difference is now, at 9th floor, +0.458 in. and at 1st floor +0.334 in. The summertime pressure difference is now at 9th floor +0.355 and at 1st floor +0.442. For these pressure differences, the volumes at the extreme levels when 200 cfm is delivered to the 5th floor are now:

Winter, 9th floor, at pd + 0.458 in. = 214 cfm
Winter, 1st floor, at pd + 0.324 in. = 183 cfm

Summer, 9th floor, at pd + 0.355 in. = 188 cfm
Summer, 1st floor, at pd + 0.442 in. = 210 cfm

A comparison of these air volumes with those calculated for 0.04 in. assumed pressure drop as is found in the average system shows a most remarkable difference and actually the amount of air delivered to the first floor during the summertime is 12 per cent greater than that for the 9th. It is not perfect, but it is certainly very close to the limits allowed in balancing an average system with an anemometer, direct reading air velocity meter, or other similar instrument. The wintertime differences in air volumes for straight ventilation purposes are certainly insignificant, and if closer tolerances are desired, one need only design a higher overall pressure difference.

One method of design to aid in a cooling system to prevent overcooling the lower floors in this instance would be to place the air handling equipment in a penthouse on the roof of the building and feed downward. In such a downfeed system, the excess air delivered to the lower floors would be at least partially offset by the temperature rise of the cooling air through duct heat gain and the total cooling effect would be more nearly equal at all levels. The converse of this would be true for an upfeed cooling system.

In assuming this higher pressure drop or resistance at horizontal takeoffs from vertical ducts, care must be taken. The method by which the resistance is to be accomplished must be thoroughly studied to prevent excessive noise and excessive room air distribution velocities, because high resistance means high velocities.

Adding the Extra Resistance

There are perhaps a number of methods by which this known resistance could be injected into a system at the proper location. One method would be to insert an orifice plate at the room takeoffs, with round edge orifices to reduce the noise level if rather high resistances or velocities are required. An orifice can be sized so that the resistance through it can be rather accurately calculated, and with one at each takeoff at the various levels,

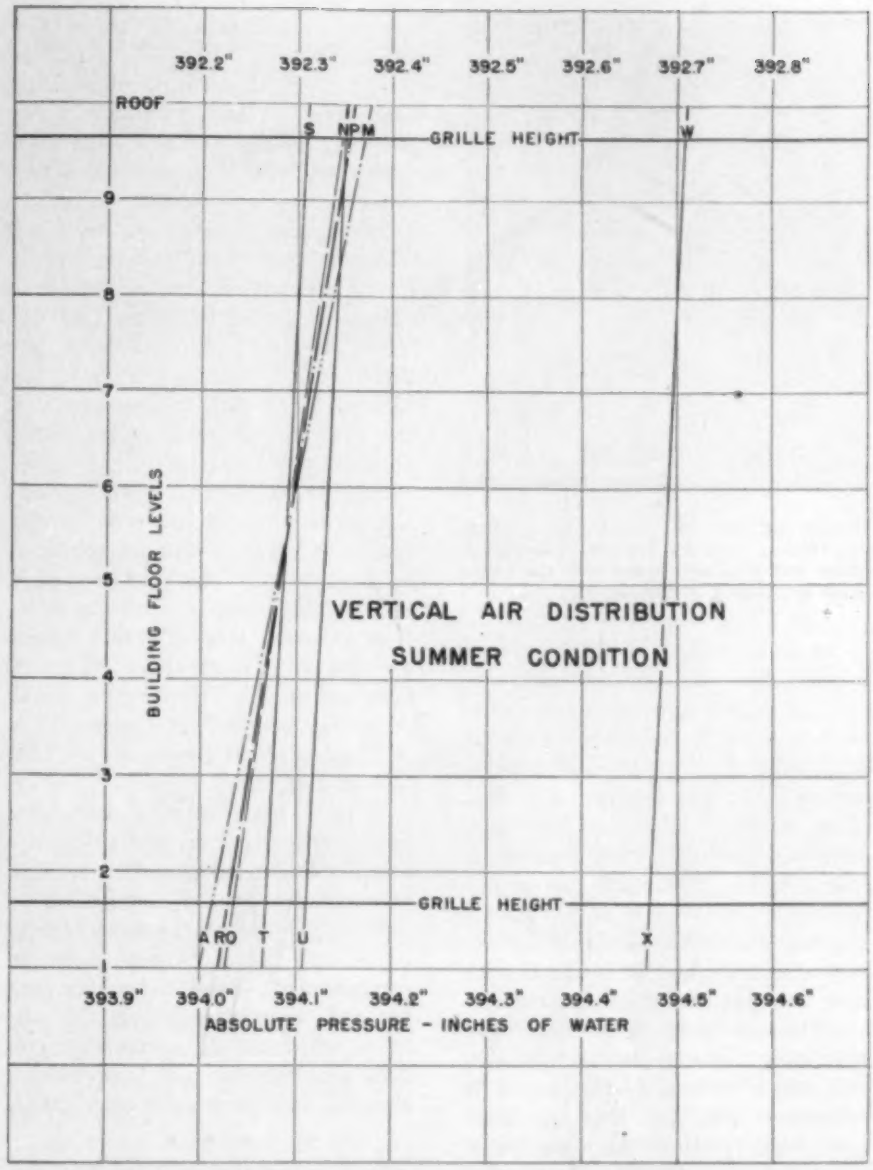


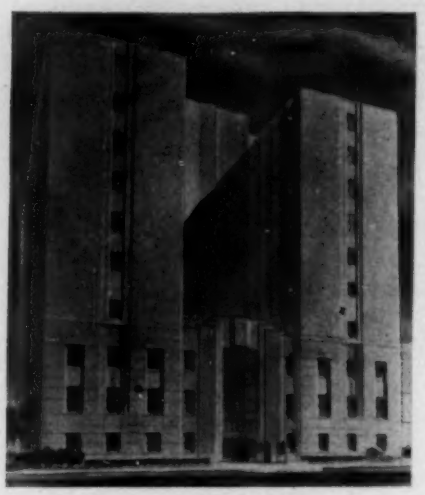
Fig. 2—Pressures at various points in nine story building under summer conditions

closer tolerances can be expected from level to level, depending upon the resistances involved and the total height of the system.

A modification of this might be to use plates at the various levels with each plate having several orifices of equal or identical areas for equal air delivery. This would offer some latitude in adjustment after installation, and if it is decided that the air deliveries are not uniform enough, one or two of the orifices *in every plate* could be closed. If in closing an orifice or two in each plate results in adding sufficient resistance to the system, the fan may have to be driven somewhat faster (depending upon its design) to overcome this additional resistance.

Except in industrial work it is not very likely that these orifices could discharge directly into the room they serve, and in commercial work some sort of plenum chamber would be required to permit reduction of air velocities, as well as provide an opportunity to install some sound absorbing material should the velocities be found noisy.

If in the design of the system unequal air volumes are required at various levels, these orifice plates need only to be designed with identical velocities through them with reasonable care to have proportionately shaped edges on any size orifice. This means that if a total orifice area of, say, 15 sq in. is required for a flow of 200 cfm, an orifice area of 30 sq in. would be needed for 400 cfm, resulting in equal resistances through each plate.



Design of the air conditioning and ventilation systems for the Cleveland clinic building conforms with the solutions explained in this article

Another method would be to add a resistance medium, such as a section of an air filter or similar material, using a calculated area at each takeoff to give a definite resistance for the desired air flow. Though such resistance may vary with the service period because it might collect dirt, each one in the system would vary a proportionate degree, and they all could be removed and cleaned or replaced with new units at periodical intervals.

Naturally there is an additional operating expense to such a system, but a vertical system would be valueless without this so-called additional friction. As a matter of comparison, a 10,000 cfm system operating 12 hr a day with $0.02 per kw electricity and 0.4 in. more friction in the system would have an increased cost of only $80 per year, a small price to pay for uniform air delivery in any ventilating or cooling system.

"Induced Draft" System

There is available today at least one design of vertical systems in which the air delivery fluctuations, with atmospheric or cooling air temperature changes, are practically eliminated. This is the so-called induced draft system and the design feature which controls the delivery of practically uniform air volumes on each level, regardless of primary air density or atmospheric conditions, is the pressure required at the primary air outlet to induce secondary air flow into the unit. This pressure is usually carried at 1.0 in., which is equal to an air velocity of 4000 fpm. The manufacturers of these units have done some fine work in making these units practically noiseless even with this extremely high velocity. Because of the low density of 40 F primary air as used in some of these induced draft systems, it is fortunate that 1.0 in. static pressure is required to induce the desired amount of secondary air through the units as designed.

Since the 1.0 in. SP required at the primary air outlets for these units provides uniform air delivery under varying primary air temperatures, one might ask why is the elaborate valve or damper required in these units? The answer is that in the high velocity duct distribution systems, large friction losses are incurred, and these dampers must adjust for the varying static pressures in the duct system. This is illustrated in principle by line *G-J* on Fig. 1.

With a high velocity duct system, it would not be unusual to encounter 4.0 in. SP at units near the primary air fan, as compared to only 1.25 in. SP at the most remote units, and this difference must be compensated. Once these dampers are set, then fluctuating air volumes, which usually occur with outdoor and primary air temperature changes, are practically eliminated.

* * *

This article does not present an infallible solution to this problem but it offers a means of approximating what stack effect does to ventilating systems in tall buildings and how to compensate for it. It is a start in solving a peculiarity of vertical systems which has received little attention in the past.

In conclusion it is evident that in a vertical duct system where the pressure differences between the ducts and the spaces being served are small in comparison to the pressure differences caused by stack effect, the air deliveries will be erratic even to the extent of being opposite in direction and not as the designer intended. However, if the pressure differences between the ducts and the space is large in comparison to pressure differences caused by stack effect the air flow will be more nearly like that which was intended.

STERILE AIR FOR SUBWAY RIDERS

New York's millions of subway riders may some day be reading their papers under glareless fluorescent lights, breathing electronically cleaned and germfree air, and starting and stopping with the smoothness of "a canoe on a lake."

This approaching millennium is heralded in the announcement of details of a new 10 car laboratory subway train recently ordered by the city's board of transportation and expected to be in service late in 1948. The Westinghouse Electric Corp. will supply the train's special air handling, cleaning and sterilizing equipment, as well as the fluorescent lighting and the electrical controls that smooth out starts and stops.

Each car will have two automatic air handling systems, one to recirculate electronically cleansed and sterilized air, and the other to bring new, sterile air into the car.

Electrostatic Cleaning

All new air being drawn into the car and all recirculated air will be blown past groups of sterilizing lamps. In addition, the 3000 cfm of incoming air will also be subjected to two separate dirt removal processes. The first is a series of cyclonic cells in which the air is whirled rapidly so that centrifugal force throws out all large dirt particles. The air then speeds through an electrostatic dust precipitator.

The recirculating air system, which draws air from the ends of the cars and redistributes it from a series of draftless ceiling vents, will handle a normal volume of more than 5000 cfm per car. However, in warm weather or when the car temperature rises because of crowding, automatic thermostatic controls will double the power output of the blower motors and boost air circulation to 6640 cfm.

New air will be taken in through grilles in the roof over the motorman's cabs at both ends of the car and led through ducts to the cleaning and sterilizing equipment, which will be mounted under the car. It will then be distributed the length of the car through diffusers mounted under the seats. In winter it will also be heated electrically as it passes through these diffusers.

R. G. Vanderweil Explains Confusion of Different Methods, Tells How to Arrive at Common Basis for Design

Practical Pointers on RADIANT HEATING DESIGN

THAT MANY ENGINEERS are confused by contradictory statements on the design of radiant heating systems has been brought out repeatedly in forums and open discussions on the subject attended by the author. The purpose here is to point out some of these contradictory statements and to re-state basic principles inherent to all proper design methods. Let us continue from our consideration of panel heat output published in the July issue:

Tube Heat Output and Panel Loss

The information contained in the literature stems from two distinctly different methods of attack. One (the "old" method) is purely empirical. Based on previous experience and interpreted rather crudely, it gives the heat output per square foot of tube surface. The second and "new" method is analytical—based on elementary physical laws proved by tests—and considers the tube surface as well as the tube spacing. Before these two computation systems are compared, it should be stated that the tube *spacing* is of greater influence upon the tube output than is the tube *surface*.

An actual comparison of the two methods of attack is made by the following example. The first method states that the tube output in Btu per sq ft of tube surface per F temperature difference water to air per hr is 3.5 for a plain concrete floor and 3 for concrete slabs with wood flooring.

In order to compare numerical values, the results of the second method (which are generally given in Btu per sq ft of panel surface) are transformed to unit output per sq ft of tube surface; we see that for ½ to 1 in. tube this output actually varies from 2 to 6.4 in plain concrete, and from 0.7 to 3 Btu per sq ft of tube surface per hr per F in concrete slabs with wood flooring on sleepers. More complete data are given in the accompanying table.

CONTRADICTORY statements on radiant heating design are "a dime a dozen" at any meeting or forum on the subject. Mr. Vanderweil — project engineer with Chase Brass & Copper Co. — explains the reasons for some of these contradictions and presents information pointing the way to an understanding

The values in the table are for a very well insulated floor panel on the ground with tubes imbedded 3 in. under the slab surface. Values according to the "new" method are conservative and correct within relatively close limits in spite of smaller variations of the conductivities of the individual materials used.

In certain intermediate slabs, the old method deviates from the new one as much as 200 per cent but is still used extensively. Let us see why. Assume we have based our computation on the old method and found a water temperature of 110 F required to heat a panel in a 65 F room. Then, in operation we

would find that the water temperature has to be reduced to 80 F to compensate our 200 per cent error. With this reduced temperature, the system would still operate satisfactorily. However, if the error is 66 per cent in the low direction, we would have to increase the water temperature to 200 F. Such increases have actually occurred and caused considerable trouble in a few special cases.

Fortunately, most practical cases result in a temperature closer to the old recommendations, as may be seen in the table. Quite typical is the case where tubes are 18 in. on centers in wood covered floors. Then, assuming that a 1.125 in. OD tube (or pipe) is used, the unit output would be 1.8. If, according to the old recommendations, we had assumed an output of 3 instead, we would have computed a water temperature of 130 F. However, having a system of a unit output of 1.8, we will find the actual maximum operating temperature to be 170 F, which is still workable. (Upon removing the wood floor, our coil would deliver the same amount of heat with a water temperature of only 115 F. Hence, if a floor covering of any type is applied, the water temperature must be raised.)

Concluding the comparison of the old and new methods, let us remember that the accuracy of the old method is questionable. Forunately, design errors can generally be corrected by regulation of the water temperature and serious difficulties have occurred in only a few instances.

Comparison of "Old" and "New" Methods of Figuring Tube Heat Output

Method	Tube or Pipe OD in.	Tube Output in Btu per Sq Ft Tube Surface per F Diff. Air-Water per Hr			
		Concrete floor		Wood on sleepers on concrete	
		6" pipe spc'g.	18" pipe spc'g.	6" pipe spc'g.	18" pipe spc'g.
New	0.625 1.125	3.68 2.07	6.44 4.15	1.26 0.72	3.0 1.8
Old	Any	3.5		3.0	

Hints on Tube or Pipe Spacing

A few hints as to tube or pipe spacing should be given. Wide tube spacings are unfavorable in plain or linoleum covered concrete floors. In such cases it will be found that an 18 in. spacing will give spotty heating, resulting in hot strips directly above the tube. Different conditions are met as wood floors or carpets are applied to the slab which will act as an "insulator" on top of the conducting concrete. Heat will distribute more readily throughout the slab under the wooden floor surface, which therefore will be of more even temperature with 18 in. tube spacing. On ceilings where tubes are imbedded in material of lower conductivity (such as in gypsum plaster), tube spacings must be smaller. Five to 10 in. are accepted values but in the ceilings as well as in the floors the heat output per square foot of tube surface increases with increasing tube spacing.

Regarding the tube diameter, it may be seen in the table that for floors (and the same is true for ceilings) smaller OD's have greater surface emission rates. This results in a rather interesting conclusion: namely, that the same structure can be heated to same temperature by the same coil when using the next smaller tube diameter and raising the water temperature a few degrees. For instance, a ceiling coil using ½ in. tube on 6 in. centers is operated with 140 F mean water and delivers 57 Btu per sq ft of panel per hr. By raising the mean water temperature to 146 F, ⅜ in. tube may be used on 6 in. centers in the same structure and still deliver 57 Btu per sq ft per hr. Therefore, let us note, the pipe or tube diameter is governed usually by pressure drop considerations or joining procedures and not by heat flow requirements.

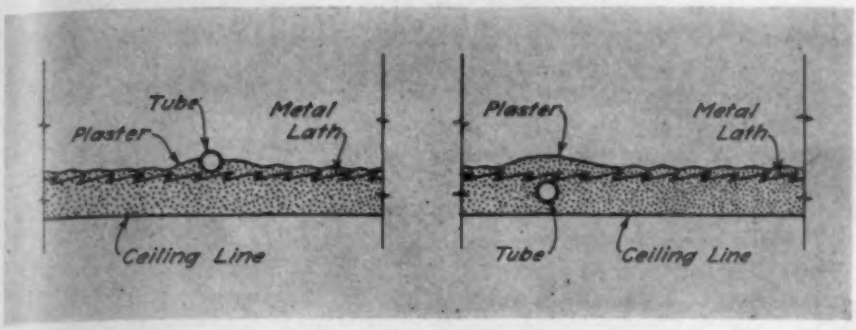
The minor importance of tube surface is indicated again by the two types of ceiling installations shown in the accompanying sketch. Although in an installation as shown at the left only little better than one-half of the tube surface is in direct contact with the plaster, a coil installed according to this sketch can supply the same amount of heat as a coil installed according to the sketch on the right by merely operating at a slightly higher water temperature. However, there are limits to the restriction of the contact between tube and plaster. If the contacting area is too small, the water temperatures called for would be too high and might cause serious calcination in the mass of plaster which was forced through and above the metal lath to contact the tube. This, in turn, might break the contact between the tube and plaster and consequently might result in underheated rooms. Similar conditions have occurred in at least one installation and have caused difficulties.

Variations in Heat Loss

The variations of the panel heat loss are even greater than those of the tube output.

In intermediate floor structures —for instance, where a coil is imbedded near the ceiling surface of the slab and the floor above is covered by linoleum—the ceiling panel functions practically as a floor panel and its heat loss (upward) may amount to 120 per cent of the heat output (downward). Where floor coils are located in slabs on damp, highly conductive ground and heat small buildings, the heat loss may amount to 80 per cent; in ceiling panels of frame buildings, to 20 per cent; and in large floor coils on dry ground, such as in industrial buildings where the edge losses are relatively small, to 5 per cent or less.

Unfortunately, the old method of computing tube output and panel losses is unsatisfactory and often wrong in defining the heat losses for various panel structures. At best it may be considered as a hit or miss method which (as do all such methods) causes difficulties where it misses. Most common is that of overheating the floor "above" or "below" and also that of under-dimensioned boilers in the case of floor panels. Where the ground loss of panels was assumed to be 20 per cent and actually proves to be 50 per cent, the boiler may become too small to carry the load. Although the new and analytical methods are not entirely



The tube surface in contact with the panel structure influences the operating temperatures but slightly. A coil installed according to the sketch at the left can supply the same amount of heat as that shown in the right view by merely operating at a slightly higher water temperature

complete, they have given the panel losses for over 100 structures within relatively close accuracy.

One of the controversial items in radiant heating design is the allowable temperature drop in the heating coil. This drop is closely related to the coil pressure drop and to the system pump head, which will be discussed first. Next, the various recommendations concerning temperature drop of the water circulating through the coil will be taken up and it will be seen that, although contradictory data exist in the literature, all statements made good sense on close scrutiny.

Essentially, the coil pressure drop is restricted by two factors—the maximum allowable flow velocity and the available pump head.

The flow velocity is generally lower than 5 fps but should by no means exceed 7 to 8 fps in order to avoid "sounding board" effects. However, as we design our system we will find that—due to pump head restrictions—in only a few cases such great velocities are used. In the small home we use a 3 ft pressure drop per coil with standard circulators or a 7 ft drop when using high speed pumps (which are available within the same price range as standard circulators). Such pumps use the same fractional horsepower motors as the standard design and may be applied to great advantage.

If we design a large building we may want to use pressure drops as great as 15 ft per coil. In such cases the flow velocity should be checked in the coil as well as in mains. In very large structures several pressure drops should be assumed and a comparison should be made of annual operating costs of pumps and amortization of piping, coils, and other equipment.

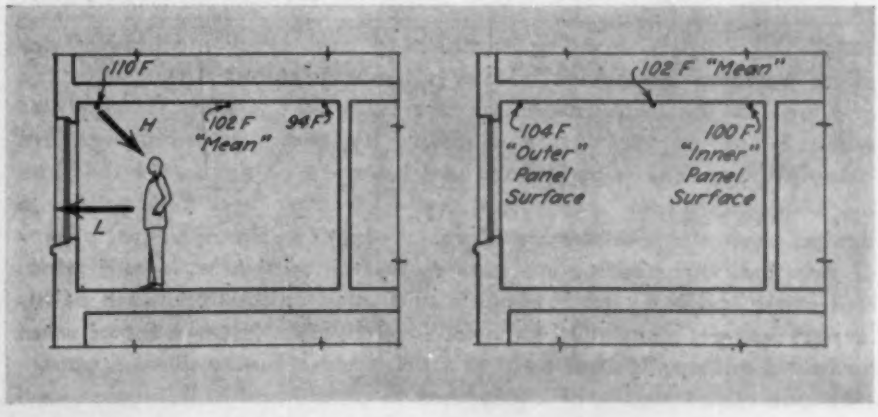
Coil temperature drop recommendations in the literature vary from 10 to 30 F. Lower drops are generally used for floors and higher differentials for ceilings—for good reasons. The proponents of a 10 F temperature differential can point to one important fact supporting their argument for floors. Naturally, where tube is imbedded under shallow concrete layers and no wood flooring is applied, we cannot accept operation on 30 F water temperature drop which might cause surface temperature variations of 15 F. With a restriction of the floor surface temperature to 85 F, this drop would result in nearly ineffective panel sections; that is, in surface temperatures near 70 F. Hence, in plain or linoleum covered concrete floors, we select a 10 to 15 F drop. Different conditions are met with wood covered slabs. Here, a 30 F drop of water temperature can be applied and affects only slightly the temperature of the floor surface, which is "well insulated" from the tube.

Again, in ceiling installations where temperature restrictions are less rigid, a 30 F drop of water temperature is allowable—in fact, is recommended for the average room. In convector systems as well as with radiant heating, it is essential for maximum comfort to concentrate the heat output near the outside wall and thereby create even temperature distribution throughout the room. The assumption that with radiant heating heat losses increase by this procedure is erroneous. It is true that in installations according to the sketch with the figure of the man, outside wall and glass surface temperatures are higher than in the other sketch if the mean panel temperature in both cases is alike as shown. However, due to the fact that the occupant's heat loss to the cold outside wall or enclosure L is better compensated by heat influx H in the sketch to the left, he will feel warmer and the mean panel surface temperature may be lowered. Hence we find approximately equal heat losses in both cases and better comfort due to more even temperature distribution in the left sketch.

This shows that a relatively great temperature gradient between "outer" and "inner" panel surface is desirable and the most efficient method of providing this gradient is to design for greater coil temperature drop.

Again, there are exceptions to this design rule. If we consider an industrial building where heat losses through the ceiling are prevalent, the floor panel temperature should be maintained at nearly constant level throughout the building.

It is desirable to increase the panel surface temperature near glass and outside wall; this results in more even warming up of the room. The sketch at the left shows how the excessive body heat loss by radiation to cold glass surfaces (L) is compensated for by additional heat input (H) from the warm panel section



John H. Clarke
Writes of
Piping Problems

Design Engineer Reports on Operating Experience

WHILE AT THE dock at Wellington we took on all the necessary supplies and water to make the trip to our next port—Abadan, Iran. Taking on the water was always interesting because the first job was to find an adapter that would fit our hose. We had standard fire hose threads. The shore connections were British threads. And just to add interest to the procedure, the shutoff valves were left-hand closing, in accordance with the usual British practice. It is indeed disconcerting to grab hold of one of these left-handed valves when you want to shut off a line in a hurry.

Before leaving the dock we shut down the plant for a short while to grind in the root valve to the 150 psi aft deck steam. This valve had been leaking considerably, and with other valves leaking in the branches there had been quite a nuisance caused by casual water floating around in the aft passageway going to the steering gear flat. To accomplish the shutdown, the auxiliary steam from the internal desuperheater had to be secured. It was therefore necessary to cut out the boilers and the auxiliary turbines at the same time, as well as all other auxiliary equipment. The grinding in had to be done by flashlights as we had no shore lighting connections available.

While the valve was being ground in we got a deluge of water which had backed up and come out the open valve. The second stage heater condensate discharges through a common line, with the discharge from the atmospheric drain tank pump to the deaerating heater. Apparently the water had backed up from the deaerating heater through a check valve, had filled the second stage heater and backed up through the reducing station and out the open valve. This is one theory. But it is also possible that the water backed up through a drip trap (inverted bucket type) which drained the reducing station and discharged to the deaerating heater through the same line as the second stage heater and the drain tank. This probably set the stage for another bit of trouble we had following this incident.

As soon as the valve was ground in and the bonnet bolted back on, we opened up the auxiliary steam lines, cleared them of water, and used the residual steam pressure on the boilers to heat the fuel oil and get the port generator going. The port generator was a 50 kw unit, about 25 kw shy of what we needed to start the plant up properly. About all it would carry was the fuel pump and one forced draft fan (both at low speed, of course), and the salt water circulating pump, which provided cooling water for the turbine driven feed pump. So we exhausted the generator to the atmosphere. As soon as the steam pressure was back up to normal on one boiler, an auxiliary turbogenerator was started, also exhausting to the atmosphere, and power was switched to this unit. The various auxiliaries (including the auxiliary circulating pump and auxiliary air ejector) were then started and as soon as we had a good vacuum we switched the exhaust to the auxiliary condenser. The main unit was then started and the ship was prepared for sailing.

HOW DO PIPING, heating, ventilating and other mechanical designs perform in service? How is the equipment operated? The answers to these questions were among the author's objectives when he (a marine design engineer by training and profession) shipped on a tanker as junior third assistant engineer. By the time his seagoing phase was completed (he's now back on land as a design engineer with the Standard Oil Co. of Indiana) he got plenty of practical information on piping, pumping, heating, ventilating, and other subjects. His comments and observations on much of his experience are continued here from our August issue—a lot of what he found out applies not only to marine work but to design, operation and maintenance of equipment in plants and buildings as well

Trap Bypass Valve Causes Water Hammer

Getting back to the incident mentioned above, for the next two months we were treated to the most unearthly steam squeal and chatter every time the atmospheric drain tank pump started up. We thought it might be that the discharge check valve on the second stage heater condensate line might be held open by an obstruction and that the steam (flashed steam) and hot water hitting the comparatively cool water from the drain tank might be the cause of the trouble. But even during several subsequent shutdowns the chief wouldn't permit us to open up the check valve to see if this was the case. So everyone on the ship aft lost sleep from this terrifice noise and pounding which sounded like a series of snare drum crescendos, each one climaxed with a boom like a bass drum. Incidentally, prior to this time, pounding or water hammer had been encountered in this condensate line when the atmospheric drain tank pump was in operation. For this reason, on some of the later ships the second stage heater drain was provided with an additional connection permitting it to drain to the atmospheric tank and thence to the deaerating heater.

I accidentally stumbled onto the reason for this new water hammer. One day, while checking the reducing stations just on general principles, the various valves on the drain lines from these stations were checked, and it was found that the trap bypass valve on the drain from the 150 psi reducing station was about a turn open. When the valve was turned off, the noise suddenly ceased. With the valve open it started up again. So *that* was our trouble. It was this live steam, discharging into the common line from the second stage heater and atmospheric drain tank to the deaerating heater, that was causing the noise.

Condensate Temperature Control

Water hammer seemed to be one of the best things we had on the ship and certainly the most annoying. For instance, on this ship both the wash water heater and the galley water heater were of the horizontal type with "hairpin" coils. But they had been installed in the vertical position, and then to make matters worse, they were provided with condensate temperature control. I have no quarrel with condensate control and where properly installed and where hot water is being used on a nearby continuous basis, it will give good service.

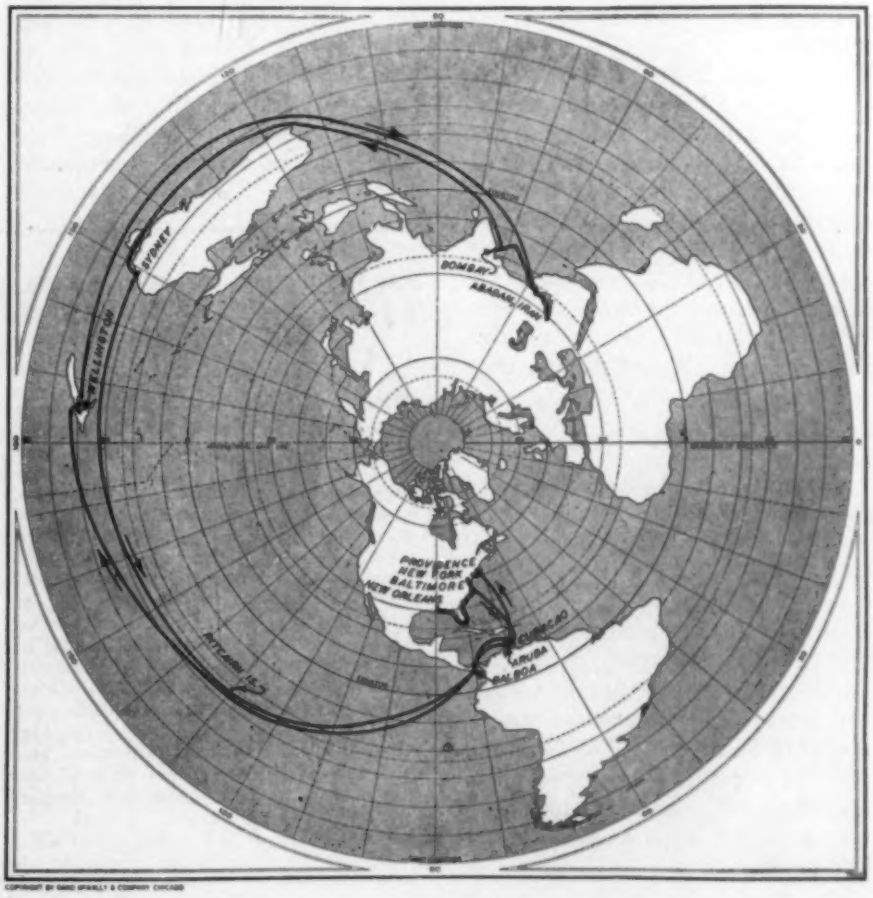
But this installation was no place for such a control. Even with steam control, water hammer would have resulted. With the condensate control, the noise was terrific—so much so that we usually bypassed the control valve long enough to get the water out and have some peace and quiet for awhile. The pounding was evidently sufficient to ruin the control valves, and for practically the entire trip there was no evidence that they were controlling to any degree whatsoever.

This difficulty had been called to the attention of the proper authorities and to the attention of the heater manufacturers during the latter part of the tanker building program, but the design change was finally accomplished on only a few of the ships. Being an elementary design problem, the correction should have been made early in the building program. Probably (and as is usual in the marine industry) the trouble reports didn't get back to the design engineers. But that is no excuse either for the engineers, nor the heater manufacturers, who knew that they were being installed in this manner. In all fairness to the latter, it should be mentioned that when the *engineering department* of the manufacturer learned how the tanks were being installed, the change to a tank designed for vertical operation was promptly made.

Loose Handwheels Dangerous

While still at Wellington, we had a rather narrow escape from a serious accident. A 12 in. handwheel fell off the inverted bypass valve of the dump valve (backpressure regulator) on the 10 psi line. This handwheel missed an oiler by about 2 ft; had it hit him, it undoubtedly would have seriously injured or killed him. This instance of a valve handwheel falling off was no isolated case. We probably had in ex-

A lot of practical piping, heating, and ventilating problems came up during the author's career as junior third assistant engineer on a tanker. Much of what he found out applies to plant and building mechanical designs as well as ships



cess of three dozen of them fall off during the trip. Some method of preventing this is supposed to be provided for the handwheels or the handwheel nuts. It is an item that should never be overlooked in purchasing a valve. A *loose* handwheel can be dangerous. A *lost* handwheel in an emergency can be very serious.

Leaving the unloading dock, we moved out into the harbor and anchored for the night, preparatory to sailing in the morning. Shortly after anchoring I was in the engine room and heard an unusually loud thump followed by a number of minor pounds—apparently from the extraction lines. So I went below and immediately opened the drains for the extraction lines. These drains stayed open, incidentally, for the remainder of the trip and it was the first time that they had been open except for the drain from the 8 psi absolute line which had been opened several times at sea a week or more previously when the pounding in that line had been unusually severe.

For some reason, I did not think to check the extraction stop valves for damage. About three or four hours later, the third assistant was on watch and in going below happened to notice that the 10 psi extraction valve was again broken. But whereas it broke at the base of the yoke at the Panama Canal, this time it broke across the top of the yoke. There was nothing to do but to turn back and have the valve repaired. So in the morning we went into a repair dock and shut down the plant long enough for them to remove the stem and bonnet and to install a temporary bonnet and stem. The plant was then restarted.

Clever Valve Repair

The valve was repaired rather cleverly by the New Zealanders and we thought that they did an excellent job of it. They made a new bonnet out of plate, brazed on two steel rods about 1¼ in. in diameter, and brazed a crosspiece across the top of the rods to form a new yoke. The crosspiece was provided with a threaded bushing for the stem and the old stem and disc were reinstalled. The bonnet, of course, was provided with a stuffing box and gland.

A Beautiful City

The delay in Wellington had its good side, too. I got a letter from home, and we were able to see much more of the city. We had already taken a tour of the bay shore, and in the added time did a bit more exploring around the city itself.

Wellington is a very beautiful city of about 190,000, located on an equally picturesque and beautiful bay surrounded by hills and mountains rising to about 3000 ft. It is somewhat reminiscent of San Francisco, being located on a peninsula with the main section on the bay, and the environs extending to the ocean (more properly, the strait between the North and South Islands) and to the narrow bay inlet. Because the area is so hilly, access to the various residential areas is difficult. Street cars serve the lower levels and busses serve the hills. They have one gravity cable railway which serves the business district and scales one of the more prominent residential hills. But we were utterly amazed at the hundreds of homes which could only be reached by flight after flight of steps—seldom less than 50 steps and often many more than that.

For such a beautiful city, the average home was in drab contrast. Most of the houses were old, of frame construction and not too well kept up. There were, of course, modern dwellings, but these were mostly in the form of apartments. On the other hand, the bay itself was meticulously clean and offered ample opportunity for swimming and boating.

Wellington is slightly farther south than New York City is north. I lost a bet on that by about seven miles. But despite this, the weather is quite mild. They seldom have snow, and it is of short duration. There did not appear to have been any appreciable development of air conditioning in the area, although this is hard to evaluate on such a short visit. One theater we visited was provided with small individual air conditioning units, but we did not notice any stores or public buildings which were air conditioned. Over and above the climate, the reason for this probably is the inability to import it at a low enough price to encourage its use.

From Wellington we were supposed to head for the Persian Gulf and Abadan, Iran (Persia). There was a considerable amount of discontent about this because the place had a bad reputation. We had already lost two of our crew at Panama. At Wellington, an oiler and a wiper walked off the ship in front of the captain and the crew. They got about two blocks from the ship when the police picked them up and returned them to the ship. But we lost four others. The score was somewhat evened by four fellows we had to take on who had "jumped ship" from the ship ahead of us to *avoid* going to Abadan. They spent the interim in the local jail awaiting our arrival.

THINGS WE NEVER KNEW BEFORE

PUNCH A HOLE IN WATER? It is done every day, as in this picture of an experimental quenching operation at the research laboratory of the United States Steel Corp. of Delaware, Kearny, N. J. But the "hole," which is really filled with invisible water vapor, doesn't last long enough for your unaided eye to catch it. This picture was taken with an exposure of 1/10,000 sec, using a square bar of white hot steel. Quenching is one of the most ancient of steel treatments and may be done in oil, air, water, brine, and many other media to give the quenched piece new physical properties—notably greater hardness and wear resistance—so steel objects you use will work better and last longer.

Charts Help to Solve LIGHTING PROBLEMS

Edwin Ira Franks Gives Graphs for Quick Check of Illumination Design and Estimating Heat from Lamps

INVOLVED THEORETICAL solutions of practical problems, although often necessary, are at times much too cumbersome to use for each individual problem. Assuming that a chart accurately represents the available data, its time-saving advantages are immediately apparent.

The air conditioning engineer is frequently faced with the problem of making preliminary cooling calculations without having exact lighting data on hand. It is then important that he make a careful estimate of the probable lighting intensities which will be encountered on the job, and from the wattage thus determined he can allow for the amount of heat contributed by the lighting to the cooling load, for 1 watt is equal to 3.413 Btu per hr. Furthermore, consulting offices doing air conditioning work often lay out the lighting as well. For these reasons, the accompanying graphs for incandescent and fluorescent lighting have been prepared.

It is not the author's intention that these curves be used for precise design work or applied blindly as a "solve-all" for lighting problems. Their principal value lies in their use as a quick check for involved calculations where the chance of large error is possible, and they have so been used in the office in which they were developed.

Lamp manufacturers' tables show that for a given lumen-watt relationship there is not a great variation in the light intensity for a given lamp wattage over the range of the various lamp, reflector, and louver combinations. Consideration must be given, however, to the following factors:

a) Shape of the space being lighted (ratio of width to length).

b) Mounting height of fixture or ceiling height of the space being lighted.

c) Reflective qualities of walls and ceiling.

d) Condition of the atmosphere surrounding the fixture.

e) Lamp maintenance (cleaning of reflectors and lamps, regularity of replacements).

Factors (a), (b) and (c) are commonly lumped together and termed the *utilization factor*, and factors (d) and (e) are commonly grouped under the term *maintenance factor*. For the purpose of this discussion, the utilization factor and the maintenance factor have been also grouped and called the *overall factor:* Overall Factor = Utilization Factor × Maintenance Factor,

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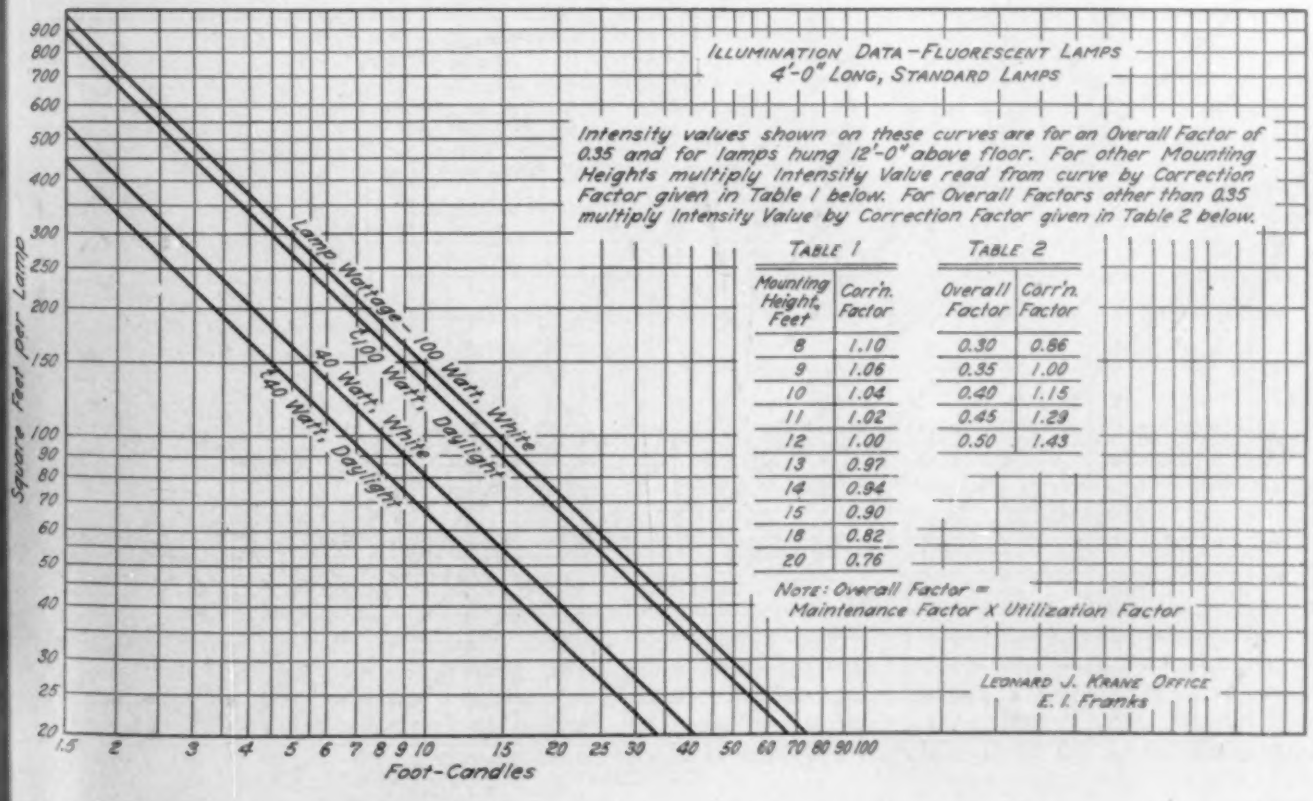

ILLUMINATION DATA—FLUORESCENT LAMPS
4'-0" LONG, STANDARD LAMPS
Intensity values shown on these curves are for an Overall Factor of 0.35 and for lamps hung 12'-0" above floor. For other Mounting Heights multiply Intensity Value read from curve by Correction Factor given in Table 1 below. For Overall Factors other than 0.35 multiply Intensity Value by Correction Factor given in Table 2 below.
Square Feet per Lamp
Foot-Candles
Lamp Wattage – 100 Watt, White
100 Watt, Daylight
40 Watt, White
40 Watt, Daylight
TABLE 1
Mounting Height, Feet | Corr'n. Factor
8 | 1.10
9 | 1.06
10 | 1.04
11 | 1.02
12 | 1.00
13 | 0.97
14 | 0.94
15 | 0.90
18 | 0.82
20 | 0.76
TABLE 2
Overall Factor | Corr'n. Factor
0.30 | 0.86
0.35 | 1.00
0.40 | 1.15
0.45 | 1.29
0.50 | 1.43
NOTE: Overall Factor = Maintenance Factor X Utilization Factor
LEONARD J. KRANZ OFFICE
E. I. Franks

where the overall factor represents the portion of light intensity generated that reaches the working surface.

Armed with illumination data published by the various lamp manufacturers, the lighting designer can determine the approximate utilization and maintenance factors for a given job. The aforementioned publications consider many combinations of lamps, louvers, and reflectors operating under various conditions of room space ratio, mounting or ceiling height of the given installation, and reflectivities of walls and ceiling. It has been the author's experience that "in-service" conditions dictate the utilization and maintenance factors used in the plotting of the curves herein presented.

To simplify matters further, the curves were plotted using the following assumptions:

A) Fluorescent curves

The lamps are hung 12 ft, 0 in. above the floor and all the light is thrown or reflected downward. The room's space ratio (length to width) ranges from 1 to 1 to approximately 2.5 to 1. Utilization factor is 0.50, maintenance factor is 0.70, overall factor is 0.35.

B) Incandescent curves

Fixtures are hung 12 ft 0 in. above the floor and all the light is thrown or reflected downward. The room's space ratio (length to width) ranges from 1 to 1 to 2.5 to 1. Utilization factor is 0.45, maintenance factor is 0.67, overall factor is approximately 0.30.

C) Both sets of curves

Lighting intensities shown on both plots are the intensities reaching a plane surface parallel to the floor and 32 in. (standard desk or case height) above the floor.

These curves represent no original investigation on the author's part. They are merely graphical pictures based on standard lamp manufacturers' data. The mathematics involved in the wattage-footcandle relationship boils down to an expression of the form XY equals a constant. This expression will plot as a hyperbola on a set of axes whose increments are equal. By using a set of logarithmic axes, the expression will graph as a straight line. For the sake of simplicity and increased accuracy this has been done. To the best of the author's knowledge no work of this nature which shows a straight-line variation has been presented, and since the graphical solutions shown offer a considerable saving in time and mental labor perhaps therein lies their value.

AIR CONDITIONING engineers must often make preliminary cooling calculations without having exact lighting data at hand, and the charts given here have been used for this purpose in a consulting office. They are not intended for precise design work or as a "solve-all" for lighting problems . . . The author was formerly with Leonard J. Krane, consulting engineer, is now with the California Electric Construction Co.

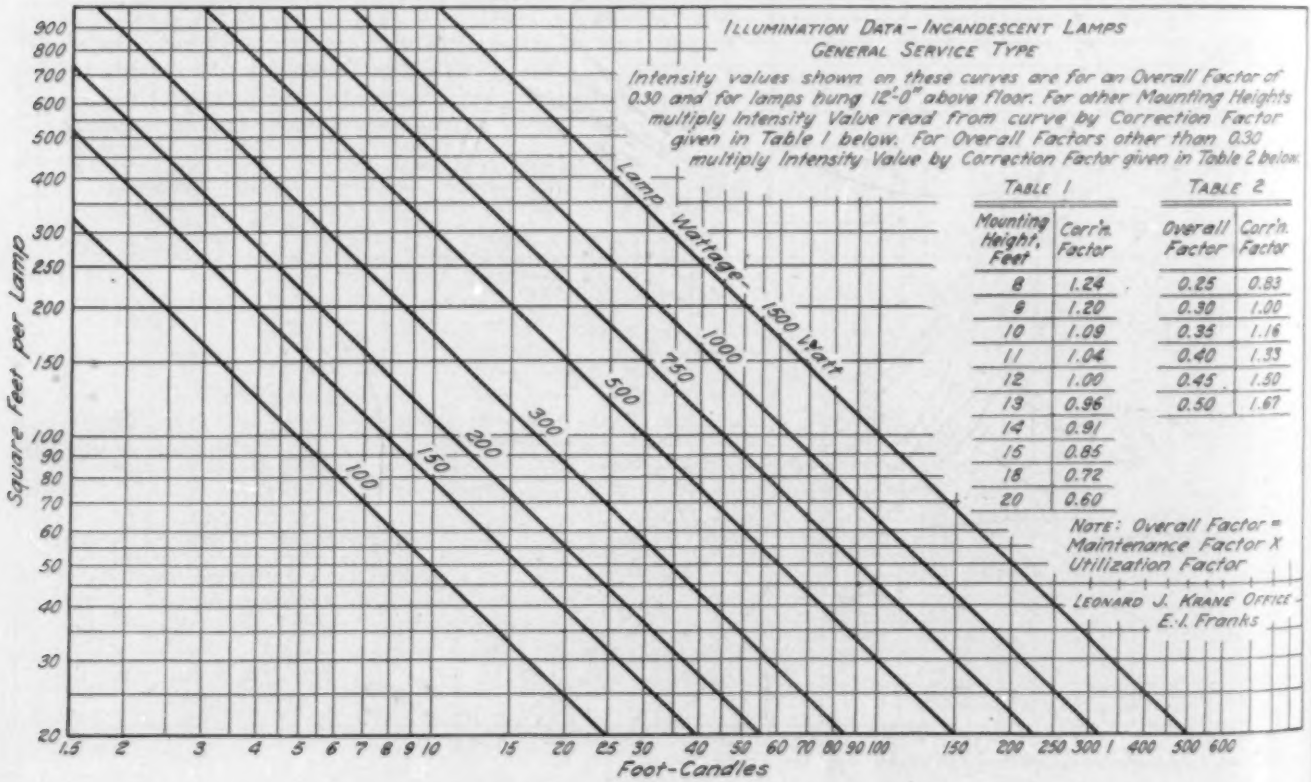
Consider a room 10 ft × 10 ft (area 100 sq ft) and a one lamp, 40 watt, white fluorescent fixture hung as previously assumed with an overall factor of 0.35.

Starting at 100 sq ft per lamp on the fluorescent curve, go to the right until the 40 watt white curve is reached. Then drop vertically downward and read the value 8.1 foot-candles.

As a second example, use the same room size with the same fixture now hung 10 ft above floor and with an overall factor of 0.40. Here Tables 1 and 2 on the graph come into play.

Following the same procedure as above, read the value of 8.1 foot-candles as a final result. Using the correction factors from Table 1 and Table 2 we have: 8.1 × 1.04 × 1.15 = 9.69 foot-candles.

Now that we are more or less familiar with the plots let us try a simple design problem. Consider a


ILLUMINATION DATA - INCANDESCENT LAMPS
GENERAL SERVICE TYPE
Intensity values shown on these curves are for an Overall Factor of 0.30 and for lamps hung 12'-0" above floor. For other Mounting Heights multiply Intensity Value read from curve by Correction Factor given in Table I below. For Overall Factors other than 0.30 multiply Intensity Value by Correction Factor given in Table 2 below.
TABLE 1
Mounting Height, Feet | Corr'n. Factor
8 | 1.24
9 | 1.20
10 | 1.09
11 | 1.04
12 | 1.00
13 | 0.96
14 | 0.91
15 | 0.85
18 | 0.72
20 | 0.60
TABLE 2
Overall Factor | Corr'n. Factor
0.25 | 0.83
0.30 | 1.00
0.35 | 1.16
0.40 | 1.33
0.45 | 1.50
0.50 | 1.67
NOTE: Overall Factor = Maintenance Factor X Utilization Factor
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Lamp Wattage
1500 Watt
1000
750
500
300
200
150
100
Square Feet per Lamp
Foot-Candles

store having a general sales area of 5000 sq ft and assume we have decided upon an "in-service" lighting intensity of 30 foot-candles using fluorescent fixtures (2 lamp-40 watt-white-4 ft, 0 in. long). Assuming conditions are perfect for a direct application of the fluorescent curves, let's go ahead and attempt a solution.

Step 1: Using any method we prefer, we first make the theoretical calculations and find that the use of 100 fixtures, each covering a floor area of 50 sq ft, will give a lighting intensity of 30 foot-candles.

Step 2: Now, knowing that each 4 ft tube is to cover an area of 25 sq ft, and proceeding as before, we find that the graphical solution for this general layout gives an "in-service" lighting intensity of 32.3 foot-candles.

In closing, a word of caution is advisable. These graphical solutions are not to be used alone for design purposes. After they have successfully checked half a dozen lighting computations, the individual engineer may take it upon himself to design his jobs graphically. Disregarding this procedure may at some time result in serious "loss of face."

[Acknowledgment is made to Leonard J. Krane, consulting engineer, and William Goodman, consulting engineer, and professor of mechanical engineering at Illinois Institute of Technology, both of Chicago, without whose counsel this work might not have been written and published.]

WHAT IS RESEARCH?

"Research" is a high-hat word that scares a lot of people. It needn't. It is rather simple. Essentially, it is nothing but a state of mind—a friendly, welcoming attitude toward change. Going out to look for a change instead of waiting for it to come. Research, for practical men, is an effort to do things better and not to be caught asleep at the switch. The research state of mind can apply to anything: personal affairs or any kind of business, big or little. It is the problem solving mind as contrasted with the let-well-enough-alone mind. It is the composer mind instead of the fiddler mind. It is the "tomorrow" mind instead of the "yesterday" mind.

—Charles Kettering

"The Gold Room on the Dream Cloud"

General Motors Experimental "Train of Tomorrow" Is New and Different

GONE ARE THE traditional upper and lower berths of yesterday in General Motors' experimental "Train of Tomorrow" touring U. S. cities this summer. Each passenger on a sleeper jump will retire to private quarters, complete with his own lavatory facilities. His home aboard the train may be called the "Gold Room on the car Dream Cloud," instead of "upper 6 in car 319"—and there's more to the designation than the difference in names. Each of the four "Astra Dome" cars—chair car, sleeper, diner, and observation car—is equipped with new electrical generating, air conditioning, and refrigerating equipment to increase passenger comfort, as well as many other features.

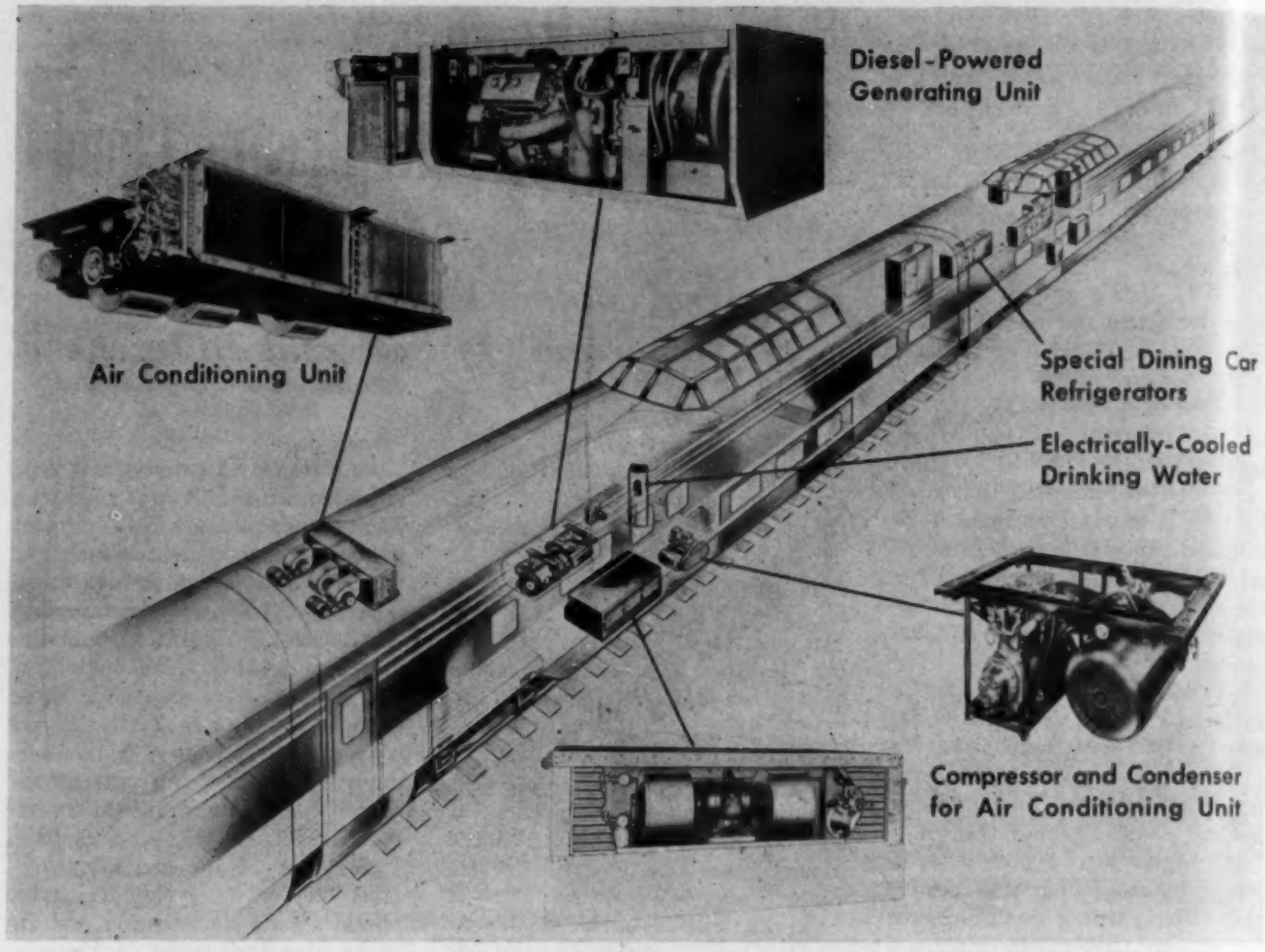
Each Car Has Power Package

An adequate source of electrical power was a necessary step in the development of improved air conditioning, refrigeration, ventilation, heating, and lighting. Ever-increasing public demands for more comforts and conveniences have amplified the need for more and better electrical power until today a single modern car requires as much as 25 kw generating capacity to supply these facilities. A fully-equipped dining car, complete with electric cooking facilities, may require as much as 60 kw. The axle-driven generating system, successful with lighter loads, has already reached the practical limit of its capacity. Large storage batteries used with this system are exceedingly heavy, occupying valuable space. Furthermore, when cars are stationary, or running at reduced speeds, the battery charge rapidly becomes exhausted.

As a result, an entirely new type of generating unit was designed for the new train. This compact power package provides each car with its own individual source of electricity for air conditioning, ventilation, refrigeration, and fluorescent lighting. The individual car power unit consists of a three cylinder, 1200 rpm diesel engine connected directly to a "split alternator" (actually two alternating current generators built on a common shaft and within a common frame). A 15 kw generator supplies 220 volt, 60 cycle current for operating air conditioning and refrigeration equipment. A 120 volt, 60 cycle generator of 10 kw capacity furnishes current for lighting and ventilation and also for radio sets, electric shavers, and other small devices. Mounted on the side of the alternator housing and driven from the extended alternator shaft is a 38 volt, 1800 rpm, direct current generator supplying approximately 3 kw. This generator excites the fields of the split alternator and charges the storage battery required for engine cranking, controls, and emergency lights.

10 Tons Air Conditioning Per Car

The Astra Dome cars, with their large areas of glass exposed to the sun, require greater refrigeration capacity than the conventional car. While the air conditioning installations on this new train are similar in many ways to equipment now in use, certain basic improvements were introduced to provide this increased capacity. Of particular importance is the flooded type, under-car condenser unit, which allows the system to operate at greater efficiency producing the extra cool-


Diesel-Powered Generating Unit
Air Conditioning Unit
Special Dining Car Refrigerators
Electrically-Cooled Drinking Water
Compressor and Condenser for Air Conditioning Unit

ing capacity required without using additional power.

A "Freon" air conditioning system of 10 tons cooling capacity is installed in each car. Six tons of cooling is applied to the lower compartments of the car and four additional tons is directed to the Astra Dome compartment.

Two air conditioning units are suspended side by side above the ceiling at one end of the car. The larger unit, which supplies conditioned air to the lower car space, consists of two centrifugal type blowers, driven by a 1 hp motor; a cooling coil; a heating coil; a drain pan to collect moisture condensed from the air; and necessary control valves and connections. The blower assembly is isolated from the car and from the rest of the unit by means of rubber mounting supports and flexible ducts. The smaller unit, which supplies conditioned air to the dome compartment of the car, is similar in construction, but has only one blower driven by a ½ hp motor. The cooling and heating coils are also smaller.

Individual diesel powered units provide the electrical requirements for each car. Air conditioning capacity is 10 tons per car

Cooling coils are divided into upper and lower sections to permit operation at one-half or full capacity. Each section has a thermostatic expansion valve to regulate the flow of refrigerant according to the cooling requirements, plus a distribution manifold, which meters an equal quantity of refrigerant to each of the parallel passages through the unit.

Finned heating coils are located directly behind the cooling coils and are supplied from a steam generator in the locomotive. Ducts concealed in the car ceiling deliver conditioned air to all passenger compartments through special discharge grilles designed to eliminate drafts. Blowers operate continuously, circulating 2800 cfm of air; 1000 cfm to the dome compartment and 1800 cfm to the lower section of the car. Seven hundred cubic feet per minute of filtered outdoor air is introduced into the system to replace air exhausted from the car and for ventilation. Recirculated air is filtered and deodorized to remove dust, smoke, and odors.

The compressor-motor unit consists of a four cylinder, vertical reciprocating "Freon" compressor, driven by an enclosed 15 hp motor. It is suspended under the car on shock absorbing mounts.

Flooded Condenser Unit

The specially designed flooded type condenser unit consists of a stainless steel enclosure in which a finned condenser coil is cooled by two centrifugal blowers driven by a 1 hp motor. The cooling effect of the air is increased by discharging water onto the finned condenser coil at the rate of 600 gph. A ¼ hp pump delivers the water to the discharge nozzles from a 180 gal tank built into the lower section of the unit. A small part of the water is evaporated on the coils and the remainder drains back into the tank and is recirculated. Baffles within the tank minimize the surging of water when the car is in motion.

Air is blown through the condenser coil from below, while the water is sprayed from above. As a result of this counterflow, the air is washed before it strikes the coil. Dirt washed out of the air is collected in traps from which it is emptied easily. A liquid refrigerant receiver within the enclosure is made of brass and the entire unit is constructed of corrosion-resistant materials. This unit is also suspended under the car.

A series of commercially available thermostats control automatically the operation of the air conditioning equipment. When cooling is required, the compressor and condenser units operate until the desired temperature is attained. The thermostatic control then automatically closes an electrically operated valve, shutting off the flow of refrigerant to the upper section of the cooling unit. At the same time, a similar valve on the compressor unit opens to bypass two cylinders of the compressor, thus reducing its pumping capacity by approximately one-half.

This modulating arrangement varies the capacity of the system according to cooling requirements, permitting regulation of car temperature and humidity within close limits, despite prevailing outside weather conditions. Thermostatic controls also regulate car heating.

Key of the control installation is a special panel which automatically determines whether heating, ventilation, or cooling is to be used in establishing the desired temperature.

Each car is horizontally zoned to recognize such factors as train speed, wind velocity, car insulation, sun load, and number of passengers. Vertical zoning establishes the relationship between overhead and floor heat so as to insure proper balance for all heat sources.

An adjustable thermostat in each sleeping compartment allows each passenger to adjust the temperature to his or her individual requirements.

Insulating Windows

All windows, including those in the raised observation Astra Domes, are glazed with two panes of glass separated by a dehydrated air space hermetically sealed in at the glass factory by a metal-to-glass bond. The outside sheet is heat absorbing, glare reducing, polished plate glass and is heat treated or tempered for extra strength. The inner glass is composed of special laminated safety glass—really two panes of glass with an inner layer of plastic similar to automotive safety glass. The plastic has characteristics which further reduce glare. Tests have revealed that these units have resisted hurled objects better than steel of the same thickness as that used in the regular roofs of the cars.

Underground Gasification of Coal

UNDERGROUND GASIFICATION of coal, suggested several years ago, already employed in Russia on a commercial scale, does not yet offer a solution to the difficulties of mining. Generally, a U-shaped tunnel is dug into the deposit of coal, with two openings at the outcrop of the seam. A fire is started in the interior of the shaft and air is blown in one of the openings. Incomplete combustion of the coal, as well as expulsion of some volatile materials, produces a gas which is collected at the other opening. The direction of flow is periodically reversed for uniform burning within the mine. The air may be alternated with steam and enriched with oxygen to increase the heating value of the gas.

Several variations of this procedure have been attempted in Russia since 1933, leading to the first commercial installation in 1940. The experiments have been plagued by cave-ins, combustion of the gas in the mine, seepage of gas to the atmosphere, and other difficulties. A particular problem has been formation of large pockets as the coal is consumed. Here the air can mix with the gas and burn it before it can leave the mine. The Lyubertsy station near Moscow has, however, produced a gas of 124 Btu heating value, using air containing 25 to 30 per cent oxygen. Two other large-scale stations were closed by the war. The Russians report that output per man can be increased from 30 tons per month to the equivalent of 100 to 120 tons per month by underground gasification. In U. S. mines, which are more highly mechanized, a man produces about 120 tons in a month of six day weeks, and in some the output is over 300 tons.

An experiment recently completed by the Alabama Power Co. and the Bureau of Mines involved the underground gasification of 800 tons of coal in a black 150 ft long by 40 ft wide. When a straight steam run followed a period of air blasting, gas with a heating value as high as 240 Btu per cu ft was produced. With use of oxygen and steam, the heating value may possibly be stepped up to an estimated 300 Btu per cu ft.

Because of the low quality of gas produced underground, gasification on the surface is projected for the $300,000 pilot plant of the Standard Oil Co. (N. J.) and the Pittsburgh Consolidation Coal Co. at Library, Pa. Powdered coal from nearby mines will be "fluidized" to react with a stream of oxygen and steam to produce "synthesis gas," which may be converted to gasoline and other liquid fuels by the Fischer-Tropsch process. The possible ultimate outcome of this experiment will be a $120 million plant to produce 400 million cu ft of gas from 20,000 tons of coal daily. In winter, when the demand for gasoline falls off, the synthesis reaction might be modified to produce more gas for domestic heating; in summer, gasoline would be produced at a maximum rate of about 14,000 barrels a day.—*excerpted from the Industrial Bulletin of Arthur D. Little, Inc.*

Corrosion in Condensate Return Lines Studied

John F. Collins, Jr., Secretary-Treasurer of NDHA, Completes His Report of Meeting

MANY PROBLEMS of the industry were given thoughtful consideration in the technical sessions of the recent 38th annual meeting of the National District Heating Association. As evidenced by the various committee reports, the most common and perplexing problem is the mounting cost of delivering steam. As a result, the attainment of greater efficiencies through reductions in line losses and corrosion, together with more accurate metering, came in for a good deal of attention.

Preventing Corrosion

The chemistry committee had as its guest speaker A. A. Berk, supervising chemist, boiler water research division, U. S. Bureau of Mines, who showed that corrosion of condensate return lines can be reduced greatly through amine treatment of the steam. He said that in a series of corrosion tests cyclohexylamine, benzylamine, and morpholine were the three amines used. It was found that in a district heating plant operated at 60 psi with 6 per cent make-up water containing 200 ppm total CO_2 and 2 per cent blow-down, 1.5 lb of either benzylamine or morpholine or 2.25 lb of cyclohexylamine were required per 500 M lb of steam produced. Since all three behaved equally under the stated conditions, a choice is purely economic.

Discussion was on the point of the cost of such treatment in plants where condensate is not returned and there is 100 per cent make-up.

The report of the steam station engineering committee was in two parts: (1) a symposium on how to protect boilers out of use from corrosion and (2) the showing of a "Kodachrome" sound motion picture of the Combustion Engineering Co., Inc., on the subject of design, fabrication, and erection of large capacity boilers.

Chairman R. B. Donworth of Pittsburgh called in succession on G. M. Johnson of Rochester, N. Y.; R. C. Hine of Baltimore, G. F. Prestwich of Philadelphia, R. G. Felger of Detroit, and H. C. Goellner of New York to describe the methods of boiler protection used by their respective companies.

The methods were the same to a very considerable extent. When a boiler is to be laid up for a long period, they recommended it be cooled, cleaned, dried and ventilated. Some utilities keep the drums open, permitting an air flow, while others place trays of a drying agent such as calcium chloride in them and close them tight.

When a boiler must be ready for service but cold, it is kept filled with water that has been chemically treated.

New Business Increasing

Several years of a "seller's market" may have dulled our wits. When the market changes we should be prepared. We should begin now by digging up new and interesting problems and by going to work in an earnest manner. In this way David W. Loucks of Pittsburgh, chairman of the sales development committee, introduced the program of his group.

New business obtained by the utilities in 1946 was reported by Arthur S. Griswold of The Detroit Edison Co. He said 31 companies signed contracts with 1172 new customers who (it was estimated) would consume 2458 M lb (M lb = 1000 lb) of steam annually and supply an added revenue of $2,320,000. He said business increases reported were 25 per cent greater than in 1945.

An analysis of the new customers revealed that 32 per cent had been served at some previous time. Lack of construction was indicated by there being only 102 new customers with new buildings. The increases represent a 7 per cent addition for

THE PROBLEMS of reducing corrosion in condensate return lines and out-of-use boilers, steam metering, and steam losses, together with reports of new business obtained in 1946, a 20 year old sidewalk panel heating installation for snow melting, and a new electrical integrator or totalizer for use with steam flow meters came in for a good deal of attention at the recent NDHA annual meeting. Mr. Collins, who begins his ninth year as secretary-treasurer of the association, completes his report, the first instalment of which was published in the August issue.

the reporting companies in both number of customers and sales.

H. L. Roe of The Dayton Power and Light Co. reported that his company had obtained a franchise to serve an additional area mostly industrial. He said a load of 13,500 lb had been connected to a new 1700 ft long, 200 psi line and 10,000 sq ft of radiation had been connected initially to a new low pressure line extension in the new area.

S. S. Sanford of The Detroit Edison Co. said his company had sold 62 new customers in 1946. These are estimated to bring in an annual revenue of $168,000.

George Wilson of Kansas City said their figure was 34 new customers added to their previous 370. He said the expected additional consumption is 45,000 M lb and the revenue $38,000.

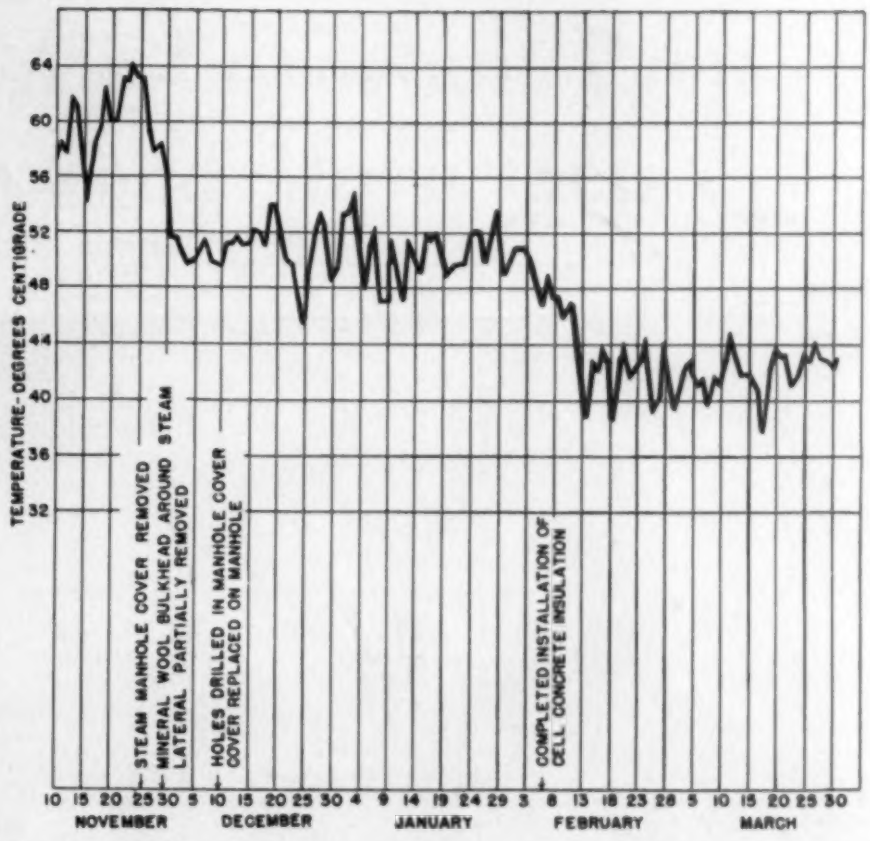
Chairman Loucks said that 49 new customers having 327,000 sq ft of radiation had been added in 1946 in Pittsburgh. The estimated use of 142,090 M lb will add $131,330 or 13 per cent to the company's revenue.

He said that a study showed that in 11 cases the primary factor resulting in the sales was a change of ownership or occupancy and in 9 cases it was enforcement of the smoke ordinance.

The committee program was closed by A. T. Veness of Rochester, N. Y., who summarized a paper by Landis Shaw Smith of his company describing a 20 year old sidewalk snow melting installation in Rochester (described in HPAC, November 1947, p. 87). The sidewalk, 2370 sq ft in area, is heated by a total pipe coil surface of 960 sq ft. The coils, of 1½ in. wrought iron pipe, are placed 14 in. below the slab surface in a space above the basement subceiling. On an average day (26 F) the cost was reported as $5.00 to keep the sidewalk clean with steam at 85 cents per M lb.

The meters and accessories committee program was opened when Walter Wisschusen, its chairman, called upon W. W. Stevenson of the Pittsburgh company to present his paper.

Pointing out that a number of types of meters are used to measure service in the industry, some for steam, others for condensate, all with some shortcomings, usually under-registration, Mr. Stevenson proposed that the committee hold midyear conferences to establish improved standards of practice to save the utilities from losses now being incurred and as a guide to utility commissions in establishing rules. He emphasized that there is no other group interested in metering for district heating and that, therefore, the committee is the logical body to seek improvement in such measurement.



The average daily recorded temperature in an empty, underground electric cable duct, in St. Louis, at a point where a 2½ in. high pressure steam lateral crosses. The steam line, insulated with double standard thick asbestos insulation, was in a rather large conduit

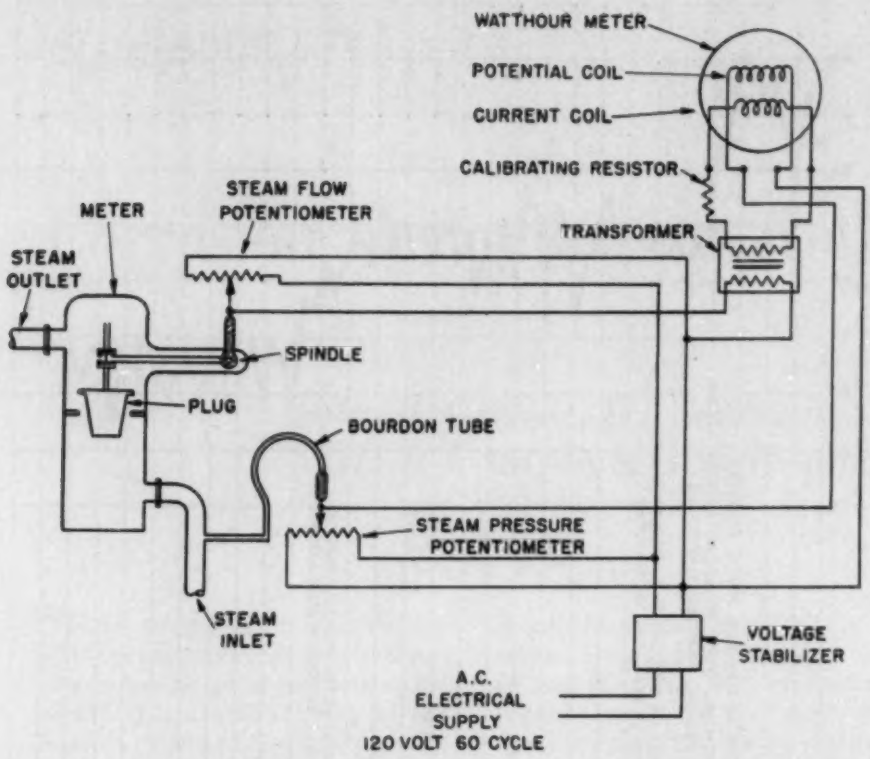
In a paper entitled Sizing of Shuntflo Meters, W. G. Gillim of the New York Steam Corp. told how his company is getting more satisfactory registration on low flows (although possibly with a shorter meter life) by considering 150 per cent of rated capacity as the meter maximum.

New Integrator

With four years experience behind him, L. A. Pagano, New York Edison Co. electrical engineer, described an electrical totalizer or integrator for attachment to plug and orifice type steam flow meters which makes corrections for pressure variation. The labor of collecting and reading pressure charts and trouble with hand wound clocks is said to be eliminated.

Richard Brown of Rochester, N. Y., proposed a solution of the steam metering problem where a customer has a high winter load and a proportionally low summer load, for example, 80,000 lb maximum demand in winter and 5,000 lb in summer. He said in one type of meter the calibrating springs can be changed each spring and fall and in another type two manometer range tubes of different characteristics can be used.

Following his introduction by J. J. Collins, of the New York Steam Corp., and chairman of the distribution committee, R. M. McQuitty of St. Louis reviewed the paper prepared by his fellow worker, V. J. Suche, entitled Remedial Measures at Steam Main and Conduit Crossings. In this paper the author explained that in St. Louis heat from buried steam lines and underground cable conduits had reduced cable capacity and had caused some cable failures. He said the remedies used which have been found successful



Electric integrator used with plug and orifice type steam flow meters. It is designed to make correction for pressure variation

are extra insulation, barriers, and ventilating ducts which divert heat and thereby permit minimum clearances between steam and cable conduits.

Julius J. Schenk, engineer of the Rochester, N. Y., company, described with the use of slides a new mile long, 10 in., 650 psi steam main, the construction of which had made it unnecessary to install another boiler in the downtown steam plant at this time.

The results reported by 18 utilities in the use of 25 brands of packing of 5 types—woven duck and rubber, asbestos rope, asbestos ring, plastic for gland packed joints, and plastic for gun packed joints—were analyzed by Paul Chenzoff of the Philadelphia company.

The general discussion which followed on distribution problems had as its central theme the desire of the companies by research or otherwise to decrease the cost of delivering steam.

Steam Losses Cut

Reporting for the first time, although the steam losses committee had been at work for seven years with interference for several years by the war, W. W. Stevenson of Pittsburgh, its chairman, said that his committee had statistics showing that in the past decade the losses—that is the difference between the amount of steam sent out by the plants and the steam sold—of the 10 largest companies had been decreased by a betterment program from 20 per cent of sendout to 15 per cent of sendout. Meanwhile 10 intermediate size companies have shown no improvement and in 10 representative small companies the losses had increased from 15 per cent to 20 per cent. He said a decrease in losses of 1 per cent by NDHA members would represent a saving of $200,000 annually. He said a typical large company had annual losses amounting to $170,000 and a small one $12,000. Figures for one company investigated indicated 70 per cent of the losses were on the utility lines and 30 per cent were on the premises of the customers or in plant metering. He said the question is how much loss can be eliminated.

To decrease these losses he recommended a high standard of construction, a persistent maintenance program, insulation, insulation protection, and careful trap inspection. He felt that metering losses should in time cease to be a considerable factor.

The tests reported indicated higher losses in the cooler months. J. J. Haroldson of Duluth read a discussion of the report by R. L. Fitzgerald of the same company. The Duluth figures show a larger total loss in the colder months but a lower percentage of loss due to the greater flow in the lines.

Martin Named President

Robert D. Martin, assistant vice president and manager of sales, New York Steam Corp., was elected president of NDHA for 1947-48. Mr. Martin is a member of the American Society of Mechanical Engineers, the New York Society of Professional Engineers, and the Real Estate Board of New York.

Another Martin, Henry L., director of customer engineering and steam utilization, Boston Edison Co., was elected first vice president of the association. David W. Loucks, supervisor of electric and steam sales, Duquesne Light Co. and the Allegheny County Steam Heating Co., Pittsburgh, was made second vice president. George H. Tuttle, station engineer, The Detroit Edison Co., became third vice president.

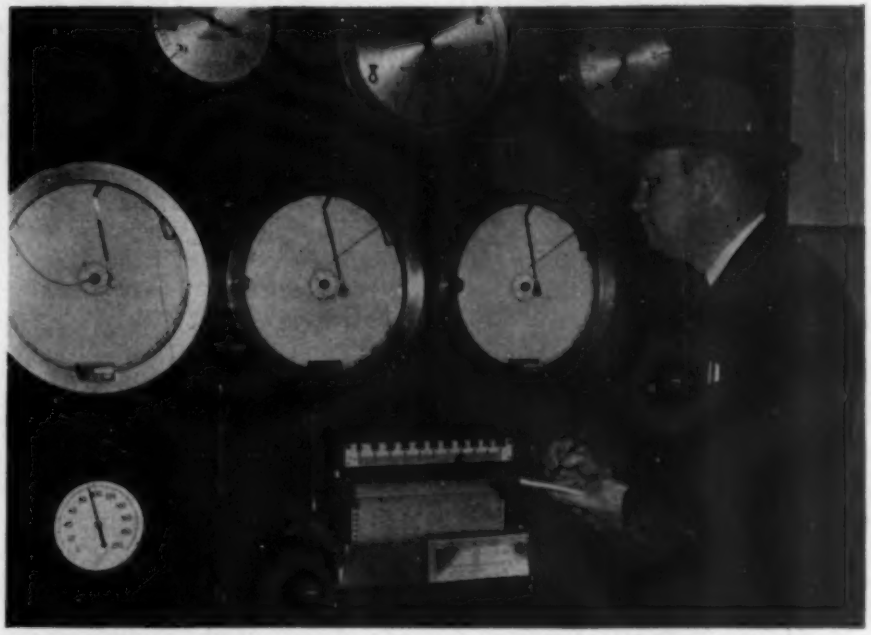
Thomas P. Brown, Jr., assistant to the manager, production department, New York Steam Corp., Percy A. Hyde, supervisor of steam heating sales and maintenance of system, Ohio Edison Co., and Milton A. Hanna, vice president and secretary, the Ric-wiL Co., Cleveland, were elected directors.

The executive board now is composed of those named above, retiring president John F. Malone, John A. Barnard, superintendent, coal bureau and steam section, Philadelphia Electric Co., Walter A. Schulmeister of S. E. Dockstader, Inc., Washington, D. C., Alfred T. Veness, sales engineer, Rochester Gas and Electric Corp., Rochester, N. Y., and the author.

BUILDING TECHNOLOGY DIVISION

A new division of building technology has been established at the National Bureau of Standards. It is made up of a number of sections and parts of sections which have come to be exclusively concerned with various phases of building technology.

Processed Air Important Prop on Hollywood Movie Sets



Through automatically-controlled air conditioning, the climate on 20th Century-Fox sound stages is always the same for the actors (and makeup men) no matter what you see on the screen. Here Louis F. Hess, the studio's veteran air conditioning engineer, reads a control panel. The recorders keep track of temperatures, steam flow, etc. The center panel charts important readings from eight precision instruments

ANYTIME AN EDITOR makes a Southern California trip you're bound to find in his magazine at least one article about the motion picture industry. Fortunately (for this editor) the American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers held national meetings there last June—as good an excuse as any to visit a busy, interesting, and beautiful part of the U. S. A. . . . Gavin Younkin, Los Angeles branch manager of the Minneapolis-Honeywell Regulator Co., describes in this article the importance of conditioned air as a production tool in the movie industry

PROCESSED AIR—which helps screen lovelies preserve their loveliness for the camera's merciless eye—is one of the most important "props" in a major picture studio's bulging bag of tricks.

By pushbutton magic—just about everything but maintenance takes care of itself—the air, cooled up to 15 ft above the stage, is also cleaned and humidity-controlled for the comfort of the players. Air conditioning, always a useful adjunct in the motion picture industry, became a necessity with the advent of color. Twentieth Century-Fox, now shooting its 65th color picture, "Captain from Castile," starring Tyrone Power and Jean Peters, is a pacesetter in both fields.

From a single instrument control panel in a central heating and refrigeration plant on the Fox lot, Louis F. Hess, veteran air conditioning engineer, can keep tabs on his vast heating, ventilating, and air conditioning system which has revolutionized picture-making.

Complete Automatic Control

"The studio's new heating and ventilating system is completely equipped with automatic controls because they simplify operation," he said.

Mr. Hess has developed and supervises an extensive operation which services 69 buildings, including an ice rink. It consists of a mile of underground pipe tunnels, seven miles of refrigeration piping, 19 miles of heating mains, two central heating and refrigeration plants, 26 major equipment apparatus rooms, and 24 minor equipment apparatus rooms.

Guarding Against Gas Explosions

A stickler on safety, he was asked to solve a problem with which studio officials had been wrestling —elimination of gas explosion hazards, particularly for people working on sets enclosed in soundproof stages.

At night, a watchman shuts off the gas to every stage on the lot and each morning before people appear on the set it is turned on. This is to prevent a possible accumulation of gas which could explode by a single lighted match on the stage in the morning.

Air conditioning has glamorous as well as comfort aspects. Here, "silent wind" from the vast air conditioning system at 20th Century-Fox studios adds an extra eye-appeal to screen star Jeanne Crain. Advantage of "silent wind" on sound stages is that there is no noise to interfere with the recording of dialogue or music, while the system still fulfills all its functions of maintaining even, comfortable temperatures and humidity—important factors in acting efficiency and makeup preservation

Even with this precaution, there was always a chance a gas line connection was broken in striking a set or inadvertently left open by workmen during the night. This would cause no serious trouble until the valve was opened in the morning, when the stage would fill with gas.

Mr. Hess evolved a simple, inexpensive, and foolproof device which exceeded the highest expectations of management (and, possibly, himself, too). It consisted of two manometer tubes, one to indicate gas main pressure and the other pressure trapped in stage pipes.

Since installation of this equipment, the watchman merely turns on the gas to the stage in the morning, lets the pipes fill up, and then turns the gas off. If the manometer lowers, a leak is indicated and no one is allowed on the set until the leak is located and fixed.

Mr. Hess' talents have found full expression in the shooting of color films, which requires air conditioning primarily because carbon arc lamps are used in producing high candlepower lighting on these sets, as opposed to incandescent lamps on black-and-white sets. The heat generated by these lamps has a variety of effects.

"First, there is the problem of the actors," he points out. "The management recognizes physical comfort is essential to good performance by players. Moreover, high temperatures or excessive humidity would cause continuous injury to makeup and clothing because of perspiration.

"Full automatically controlled air conditioning on our sound stages maintains a temperature of 73 or 74 deg, despite blazing lamps, and this permits actors to work in 'take' after 'take' without more than the most cursory attention of the makeup-man or wardrobe-man."

Hess-devised wooden ducts, which are pulled from the walls like Murphy beds and look like speakers' platforms when extended to the stage floor, make this possible. From a dozen of these on each air-conditioned stage flow Arctic breezes at a velocity of 500 fpm.

In "Forever Amber" and in many other films, "fog" is an important dramatic property. Movie fog tends to dispel, but not completely disappear. When it is used repeatedly, remnants of the last scene's fog must be removed before fog for the next scene can be introduced. The air conditioning equipment takes care of this as well as incidental smoke from dueling pieces, fireplaces, or anything a script-writer might imagine.

Moisture Affects Sound Recording

Sound, too, is affected to an important extent by air conditioning. Moisture—or lack of it—in the air so influences recording machinery it is difficult for technicians to record consistently in periods of variable weather. In sound stages not equipped with air conditioning, recording cannot be done on the set under certain weather conditions.

Air conditioning is important on music stages to keep instruments, particularly of the string and reed variety, in tune. These stages are kept at a 72 deg temperature for the comfort of the studio's 100 piece orchestra.

During the "Santa Ana season," when hot, dry air from the Santa Ana canyons blows into the Los Angeles area at a velocity as high as 50 mph, causing chapped skin and parched lips, moisture is added to the stage set air so that the human air conditioning system of the actors—the best in the world—will not go out of whack.

Moisture also is added to the air to eliminate a fire hazard—static and sparks generated in rewinding film. Automatic temperature controls, Mr. Hess says, make it possible for technicians to keep within 3/1000 of an in. tolerance per yard of film.

At 20th Century-Fox, Mr. Hess has developed a way of piping air to sets to be used as "silent wind" for romantic shots where a breeze brushes a girl's hair; ruffles her dress. This is achieved by attaching ducts to the air conditioning system. An advantage of his technique is that the breeze is silent, which is not entirely true of normal wind-making equipment.

Air Conditioning Installation Grows

Fox's air conditioning plant operated in 1935 with a capacity of 360 boiler hp, 350 tons of refrigeration, and air conditioning of 250,000 cfm of air. The present operating capacity is 1400 boiler hp, 1000 tons of refrigeration, and 1,250,000 cfm—an increase of some 400 per cent in 12 years. Provisions have been made for greater expansion of air conditioning facilities to keep pace with erection of additional buildings on the 20th Century-Fox lot. All this was planned, designed and provided for in the original installation, according to Mr. Hess.

Fox's air conditioning department installation has been designed, detailed, estimated, superintended, and operated by its own personnel.

DON'T MISS reading Equipment Developments, Recent Trade Literature, New Books & Reports, Executive Changes and Meetings & Conventions. These departments appear regularly in Heating, Piping & Air Conditioning.

QUESTION OF THE MONTH

Air Distribution in a Theater

[More answers to question from "T.L." published in July]

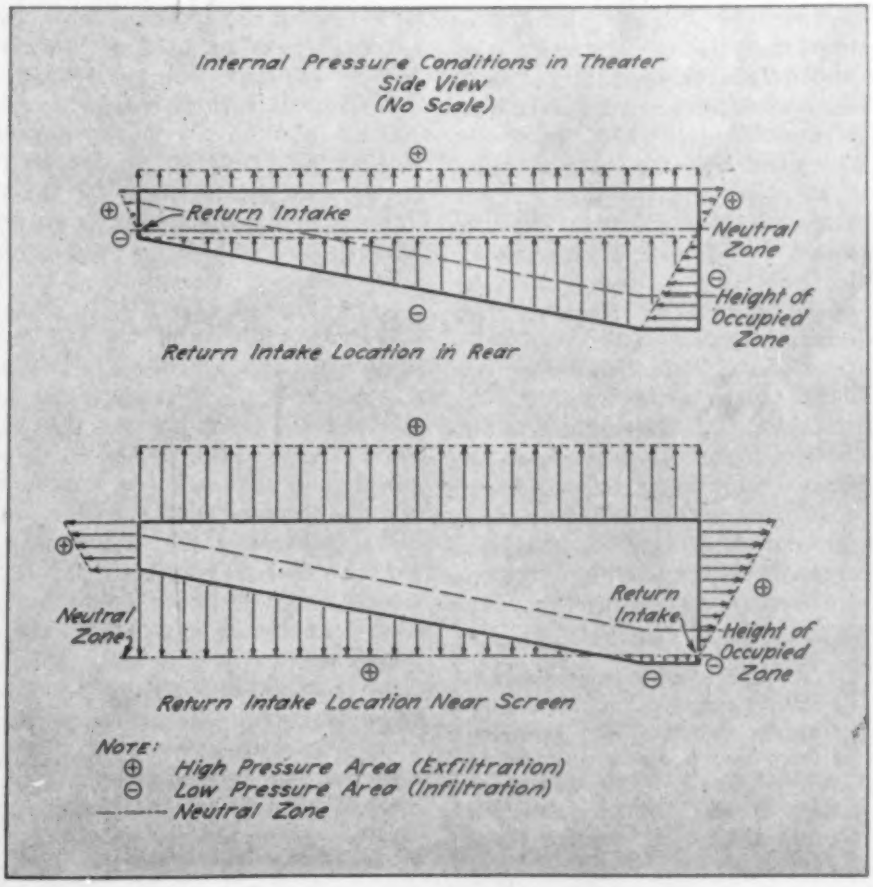
To ACCOMPLISH efficient air distribution in a theater air conditioning job, it is essential to obtain temperature equalization in the occupied zone and to prevent infiltration of non-conditioned outside air.

Even though the air supply outlets may be well selected and installed, proper air distribution is difficult to obtain in the area near the screen, where infiltration is most likely to originate from the space behind and above the stage. In this section the level of the occupied zone drops considerably below that of the rear of the theater —17 ft in the present case. By locating return intakes in the rear of the theater (see sketch), the neutral pressure zone is raised to such an extent that non-conditioned air will enter near the stage and cause an excessive temperature variation between front and rear of the space. If such infiltration is minimized by solid construction of stage and stage loft, air stagnation will result and cause discomfort due to uneven room temperatures and stuffiness. This applies to operation of the heating as well as the cooling cycle. Further aggravation of this condition would be caused by operating exhaust ventilation with intakes in or near the ceiling during periods of occupancy. (Obviously such ventilation would be advantageous and desirable before and after shows to remove vitiated air.) By installing return intakes at the lowest possible level—near the screen—(see other sketch), infiltrated air is removed at its source. The neutral pressure zone is lowered sufficiently to keep infiltration at a minimum and air stagnation is avoided throughout the entire occupied zone.

The company I am associated with has had considerable experience with air distribution problems as applied to theaters, and as a result we have come to the conclusion to insist on extracting a large portion or the entire amount of return air through intakes located near the stage at the lowest level where installation may be practical. In this respect, therefore, "T. L." is at variance with the principles of air distribution and the results of our experience.

On the other hand, he is right when criticizing the absence of any provision for exhaust ventilation and—if I understand correctly—for fresh "make-up" air. In order to provide sufficient internal pres-

By locating return air intakes in the rear of the theater (upper sketch) the neutral pressure zone is raised to such an extent that non-conditioned air will enter near the stage and cause an excessive temperature variation between front and rear of the space, says "E. G." By installing return air intakes at the lowest possible level—near the screen—infiltrated air is removed at its source, he says



sure in the enclosure to lower the neutral zone even below floor level, more air must be supplied than is returned to the air conditioning unit. The excess air may then exfiltrate either into the theater lobby or to the outside, and fresh air must be used to make up for such exfiltration losses. A ratio of 75 per cent return air and 25 per cent fresh air will usually produce satisfactory results.

Another important aspect of this problem is proper selection and location of air supply outlets in the rear of the theater, due to the comparatively low ceiling height and the (presumably) large amount of air to be handled. If ceiling air distribution is not possible for structural reasons, wall type diffusers may be required to accomplish draftless air distribution in that section.—E. G.

AIR TUNNEL DOWN MIDDLE OR SIDE OF HOUSE

IT APPEARS FROM the general information given by "T. L." that a theater 51 ft wide x 188 ft long and with a ceiling height at the rear of 8 ft, sloping down to 25 ft, that sidewall outlets would never give satisfactory air distribution.

These sidewall outlets would have to have a blow of 25 ft, 6 in. Even breaking these up into many small units, the drop for that length of blow would be around 7 ft and the air would surely impinge on the faces and bodies of the occupants.

It is my opinion that a much more satisfactory layout, as far as supply outlets are concerned, would be to locate them down the center of the ceiling. The use of, say, four ceiling supply outlets would make for a good distribution without the danger of objectionable drafts.

As far as the return air is concerned, there has never been any definite information (to my knowledge) that establishes any particular location as being the most satisfactory solution for all returns. However, for winter use, there is a definite advantage for the stage return grilles, as there is a natural tendency for colder air to settle toward the front, which is taken up by these grilles—thus preventing cold pockets in this area.

I used the following returns in past experience with very good results and I believe this scheme could well be adapted for this installation:

In theaters of this type where the floor is built directly on the ground, without basement space, we have dug a tunnel down either the middle of the house or on either side of the house. This tunnel is made of cinder, cement block, or tile pipe of proper area and was usually installed within a very short time without seriously disrupting operation, usually during the night. Into these tunnels we plugged either mushrooms or aisle type intake grilles.

I feel that the above suggestion, which I have found many times in many installations operates completely satisfactorily, would be a good solution for "T. L.'s" problem.—N. F.

DISTRIBUTE AIR FROM REAR OF THEATER

I AGREE with the conclusion of "T. L." that the system as described to both heat and cool the theater would be faulty and unsatisfactory. In my opinion, if the theater is conditioned by the described system of using high outlets along the sidewall with returns along the front, two objectionable conditions would be repeated which have been found by experience in conditioning theaters in the past years. One of these conditions is that the rear of the theater under and above the balcony will be inadequately cooled or overheated, depending upon the season. The second of these conditions is that of overcooling at the front of the theater because the slope of the floor causes the cooler air to collect there, independent of the season. These conditions may be corrected by the application of the best practices in air distribution for theaters, with which "T. L." is apparently quite familiar. However, my suggestion for such a size theater would be to distribute the air horizontally at a relatively high velocity from the rear of the theater and high across the entire width. This high velocity movement of air would cause forward movement of the air high above the occupied area. Most of the air enters the system again at the rear for recirculation and the remainder goes out into the hall and lobby. This eliminates the objectionable conditions mentioned and does away with any possibility of having drafts striking the occupants on the back of the necks.

"T. L." also mentions that there is no provision for exhausting the ventilation or fresh air. In my opinion, this is quite acceptable as some of the air from the theater auditorium should move from the rear of the auditorium through the hall and lobby onto the sidewalk, and this cannot be accomplished by having air exhausted directly from the theater auditorium itself to the outdoors during the heating and cooling seasons.—R. R.

YOU ARE invited to submit a heating, piping, or air conditioning question for publication. You are also invited to submit answers to questions from others. Those published are paid for at regular rates

CONDENSATE STEAM FLOW IN PIPE LINE

YOU ARE INVITED to comment on the following question from a reader of HPAC. Suitable discussions of this matter will be published, and paid for at regular rates (with additional payment for sketches). Address The Editor, Heating, Piping & Air Conditioning, 6 N. Michigan Ave., Chicago 2.

"I have encountered a situation where the steam supply line to a building must rise out of a main located in a steam tunnel under the street and then must run horizontally into the building. To avoid a serious excavation problem and trap maintenance difficulties, the main to the building must be pitched up from the tunnel under the street. This, of course, results in condensate flowing back against the steam flow for a run of some 50 ft. The steam in the main has a pressure of 200 psia and the pressure may be increased in the future.

"I would appreciate information relative to the critical velocity—that is, relation of pitch, steam velocity, condensate flow, etc., with reference to the source of information."—R. R. J.

SAM LEWIS' PAGE

In this regular feature, informal comment on heating, piping and air conditioning matters is given by Samuel R. Lewis, consulting mechanical engineer and member of HPAC's board of consulting and contributing editors. This month he answers a reader's questions about one pipe and two pipe gravity steam heating systems, and the condensate temperature with a one pipe steam heating system

Is One Pipe Steam System Better Than Two Pipe?

Dear Mr. Lewis:

Being a regular reader of your page in HPAC, I am taking the liberty of addressing this letter to you.

I would like very much to have your opinion on whether the one pipe steam heating system would have any advantages if the steam supply to the radiators could be controlled to the same extent as the two pipe gravity steam heating system?

I would also like to know whether the water from the radiators does not get back to the boiler at a higher temperature than with any of the other steam heating systems.

If you consider the above of sufficient interest to your readers you are at liberty to discuss it in your column. Any information you see fit to give me will be considered as strictly confidential and for my personal use only.—M.E.M.

A READER IN California asks whether a single pipe, low pressure steam heating system serving radiators would have worthwhile advantages if the steam supply to each radiator could be controlled to the same extent as a two pipe, otherwise similar, steam heating system may be controlled?

Up to date, it would be hard to sell *me* a low pressure steam heating system of either single pipe or two pipe gravity circulating type. I have never been able to find any two pipe system of the sort suggested that could be controlled any better than can a single pipe steam system. If one applies to a two pipe steam system a trap on the drainage end of each radiator, said trap willing to pass air and water but stopping steam flow, such a scheme becomes no longer an ordinary two pipe system.

If one has some sort of pump, alternating receiver, or other gadget connected to the return pipe from the traps, then he no longer has a gravity two pipe system. A two pipe system with traps, provided that the gadgets all work, and provided that the constantly accumulating air is evacuated from the return pipe, permits one to adjust the heat output from the radiator by manipulating the steam supply valve.

The two pipe steam systems that have effective vacuum pumps on the return mains and that maintain a low absolute pressure (far less than atmospheric) have been demonstrated as achieving remarkably low fuel consumption. These results are accomplished with a heat-carrying gas (steam at very low pressure) that permits variable radiator temperatures and by use of pumps that keep the pressure so low, even in the boiler, the water boils at temperatures hardly warm enough to cook an egg.

I haven't found anything that can be done satisfactorily to make acceptable the control of a single pipe gravity steam heating system. The most nearly acceptable scheme is alternately to open wide and close tightly the steam supply valve to each radiator, as by compressed air under a diaphragm working against springs or by an electric motor responding to a thermostat. There is no difficulty in demonstrating with any single pipe radiator that water hammer, wet carpets and serious damage will result eventually if there is any hesitancy or weakness or temporizing about the positive and complete closing and opening of the steam valve.

The patent office is cluttered with hopeful inventions to beat this natural phenomenon. Not any of them endured. One scheme was to provide compressed air at a pressure higher than that of the steam. If the room became too warm, this air was to be blown into the radiator to displace part of the steam. If the room became too cool, the air pressure in the radiator was to be reduced and the steam was to have enough pressure to chase the air out. The manipulation of these pressures proved complicated, and the excess air in the condensate that resulted did the piping and boiler no good.

In answer to "M. E. M.'s" second question—as to whether there is virtue in the idea that if one installs a single pipe steam heating system, a fuel economy will be

realized because the condensate from such a plant running along the bottom of the pipe that also carries the steam might return to the boiler at a higher temperature than that to be expected if the condensate runs in a separate pipe—one might conceive, in the light of this query, a plant in which the condensate comes back to the boiler as hot as the steam. It appears that in this case we would have to add more heat transmitting surface at the radiator. After all, the more heat we can transmit to the air or to the surrounding materials at the radiator, the more efficient will be the radiator. The more heat we transport out to the radiator and the less heat we carry back, the more efficient will be the radiator, and the less costly will be the materials required to do a job. The heat remaining in each pound of water condensed in the radiator is better spent in doing what business it may —out in the building—than in being carried back to the boiler. This situation appears to be true in a direct steam heating system.

In a boiler plant that uses steam to run engines, the hotter the feedwater at the boiler the better.

I remember heating a very large factory with steam. We condensed the steam to gain the latent heat of evaporation, about 966 Btu per lb of water. We then heated all the domestic water for lavatories with the condensate and had enough heat left in the condensate to warm about 10 per cent of the space in the building by running it through fan-equipped unit heaters.

Constantly one encounters central station steam heating systems where the hot condensate is trapped directly to the sewer because of the alleged difficulty or expense by the public service company in pumping the hot water back to the distant boiler plant. It is not difficult for each customer in such cases to install means for saving most of the heat before letting the condensate waste away.

I feel that there are not enough Scotsmen among the customers of such public service companies.

[*We are sure Mr. Lewis would welcome comment from other readers of his page on the questions discussed above.—The Editors.*]

Survey Indicates Much Hotel Air Conditioning

A $140,574,000 market will be created for heating, air conditioning, refrigeration, and other engineering department equipment under the $382,000,000 country-wide rehabilitation program being launched by the nation's hotels now that rigid federal controls have been brought to an end. Eighty-eight per cent of the hotels with 100 or more rooms are planning rehabilitation of their properties, and seven out of every 10 of these will make long needed changes in their engineering departments.

This great market for equipment is shown in a 100-page book which has just been issued by the Hotel Monthly, a leading magazine of the hotel industry. It was determined through a survey made especially for the magazine by the C. C. Chapelle Co., marketing consultants, on the basis of personal interviews with hotel owners and operators, according to J. Knight Willy, editor and publisher of the magazine. And, as the survey was confined to hotels with 100 or more rooms with no figures available on the market potential of the smaller hotels, the purchasing figures "actually represent a very conservative estimate."

The greatest market in the equipment field will be for air conditioning. Of the hotels planning renewal of engineering departments, 69 per cent will install new or additional air conditioning equipment. Of this group, 36 per cent will install central systems, 27 per cent will install unit systems, and 6 per cent will install both types. Hotels will spend from $37,500 to $125,000 each, or a total of $84,480,000. Hotels of from 100 to 199 rooms will spend $25,200,000; hotels of 200 to 299 rooms will spend $22,692,000, and hotels of 500 rooms or more will spend $17,750,000. The greatest percentage of buyers will be found in the largest hotels, those of 500 or more rooms, with 54 per cent of them planning new purchases.

New boilers, stokers and oil burners will be installed by 20 per cent of the hotels planning improvements in engineering departments, and new distribution and control equipment will be purchased by 22 per cent of the group.

The potential market for boilers, stokers and oil burners will be $22 million. The smaller hotels will buy one boiler, those of 200 to 399 rooms will buy two, and the larger sized hotels will buy three. Expenditures for boilers will range from $18,000 to $150,000. From $1070 to $4200 will be spent for stokers, and from $3000 to $10,000 for oil burners.

A $9 million market for distribution and control equipment will include new radiation for guestrooms, temperature controls, and pumps. The smaller hotels will spend an average of $12,850 for this type of equipment, and the largest hotels will spend about $42,700.

New refrigeration equipment costing $3 million will be installed during the rehabilitation program. Hotels of 100 to 199 rooms will spend $672,000, and hotels of 500 or more rooms will spend $1,600,000. Costs are estimated at from $1500 for the smaller hotels to $20,000 for the larger ones.

In addition, there will be a market of considerable volume for valves and plumbing, for wiring and for many products used or handled by hotel engineering departments not specifically included in the survey.

HENRY M. REED DIES

Henry Morrison Reed, 66, chairman of the board of the American Radiator & Standard Sanitary Corp., died in Allegheny general hospital, Pittsburgh, August 12, after a long illness.

Mr. Reed's entire business career was devoted to American-Standard and its predecessor companies. He was widely known and respected, not only in the plumbing and heating industry, but in business circles everywhere.

DATA SHEET

Simplified Procedure for SPECIFICATION WRITING

In the April 1946 Heating, Piping & Air Conditioning there was an article entitled A Simplified Procedure for Specification Writing, by George W. Campbell. Due to several requests, it was decided to run as a supplement to this article a series of specification cards which are currently being used by the firm of Urdahl and Everetts, consulting engineers, in their Washington, D. C., and San Francisco offices. Mr. Campbell is employed in the Washington office.

The cards have been duplicated by the "Ditto" process. After the original duplication on 8½ x 11 in. paper, the copies were cut into 5 x 8 in. cards. The "master" ("Ditto" terminology) was also cut out and filed in a 5 x 8 card file. The original cards have no dates. As the cards were revised, a date was added so that an obsolete card would not be used.

The cards are in two sections, a lettered series and a numbered series.

Let us assume a specific problem. We have designed a direct fired air conditioning system. We would go to the files and remove card No. A. Looking under paragraph 1, we note general intentions, scope of work, and time of bids. These items should be written on a 5 x 8 in. card or paper and should be given the numbers noted.

Consulting engineers and architects usually have a permanent set of conditions which they use for the particular locality in which they work covering such items as checking, definitions, delays and extensions, and accompanying drawings. These are included in paragraphs 2-31 indicated as printed matter; if we do not want to use 30 paragraphs for this material we can easily change the number.

Paragraph 32, work to be done by others, is another paragraph that will have to be written out for each job as every job will be different.

We now have arrived at the part of the system that is a time-saver. We go through the file and pick out all cards having numbers which are listed on Card No. A, following the title of the specification as direct fired air conditioning unit (1), heat exchanger (9), oil burner (11), etc. In our particular problem we won't need some of the cards. Let's assume we are not responsible for the domestic hot water system, which in this case is a plumbing job; therefore, we return card No. 39 (domestic water heater). Again, let us say the architect is to include in his specification all flashing where it is needed; therefore, we return card No. 34 (flashing).

We now take the cards and number them. Paragraph 33 of our specification will be given to direct fired air conditioning unit (Card No. 1), paragraph 34 to fuel oil tank (Card No. 23), etc. Should any of the cards now become separated, that loss will be easily detected when the secretary starts to type them.

After all the cards have been properly marked for the conditions of the particular job, we turn them over to the typist. After typing, the cards can be stapled together and placed in the job file.

The principal advantage of the system is that the engineer is saved time by not having to write out each specification every time it is desired to specify that item, and it eliminates errors which result from trying to transpose longhand. An added advantage is that an individual specification can be changed by substituting the newly written specification using the old number in place of the obsolete cards.

Several of the cards have been published in the June, July, and August issues, more appear this month, and others will follow. Because of space limitations, they are shown smaller than the 5 x 8 in. size. These specifications are not to be construed as recommendations to other consultants but only to illustrate this card file used by Urdahl and Everetts.

Card No. 18
Job No. ___

___ CIRCULATING PUMPS: Circulating pumps of an approved make shall be furnished and installed for _____ circuits. The pumps must operate smoothly and quietly without vibration, and flexible connections shall be used if it is necessary to prevent transmission of sound.

The pump motors shall be designed to operate on ___ volt, 60 cycle, single _____ phase current. The pumps shall be capable of fulfilling the following requirements:

Circuit No. ___

_____ gpm against a head of _____ inches of water pressure, using a _____ hp _____ rpm indirect connected motor.

Circuit No. ___

_____ gpm against a head of _____ inches of water pressure, using a _____ hp _____ rpm indirect connected motor.

Card No. 19
Job No. ___

___ CONDENSATE RETURN PUMP: Furnish and install _____ condensation pump having a capacity to pump _____ gpm of water at 200 F against a head of _____ psig. The receiver tank shall have the capacity to hold _____ gallons of water. The pump shall operate automatically by means of a positive acting electric float control. A float control in which the float is external to the receiver is preferred. The pump shall be the product of a reputable manufacturer and make, size, and type shall be approved before being ordered.

The pump motor shall be _____ hp and shall be wound for ____ volt, 60 cycle _____ single phase current and shall have a speed of ___ rpm.

Card No. 20
Job No. ___

___ PUMPS: The _____ water circulation pumps for the _____ _____ system shall be of the size and the location as shown on the plans. The pumps shall be designed to deliver ___ gpm of water at ___ F against a head of ___ feet of water, using a ____ hp motor operating at ___ rpm. The motors shall be wound for ___ volts, 60 cycle, _____ phase current.

The pumps shall be mounted on a reinforced concrete _____ base as shown on the plans.

The pumps shall be close-coupled double single suction, single stage, direct belt driven with a horizontally divided casing and a cast iron bronze _____ impeller.

The pumps shall be similar and equal to No. ___ type _____ as manufactured by the _____.

Card No. 21
Job No. ___

___ SUMP PUMP: Furnish and install a sump and sump pump in the manner and where shown on the plans. The pump shall be similar and equal to those manufactured by the _____. It shall have a capacity of not less than ____ gpm to operate against a head of ___ ft and shall be of a proper length to fit the sump. The motor shall be ___ hp operating at ____ rpm and shall be wound for ____ volt, 60 cycle, _____ phase current. It shall have an automatic float to control the motor.

Card No. 22
Job No. ___

___ UNIT HEATERS: Unit projection heaters shall be provided where shown on the plans and shall be similar and equal to those manufactured by the _____ The heaters shall have axial flow fans and shall be designed for quiet operation with a speed not in excess of ___ rpm. The heaters are selected so as to maintain a temperature of ___ 70 F at breathing height in the heated area _____.

The heaters shall have the capacity as shown on the plans to deliver _____ Btuh with a fan delivery of ____ cfm and with a ___ row coil.

The heaters will have the above stated capacity when supplied with water at ___ F saturated steam at ____ psig pressure.

The heaters shall have motors wound for ___ volts, 60 cycle, single ____ phase current and shall be controlled by a thermostat. A switch shall be provided so that the fan can be operated independent of the thermostat or can be turned off entirely if it is so desired.

Card No. 23
Job No. ___

___ FUEL OIL TANK: A _____ gallon fuel oil tank bearing the Underwriters' label shall be installed underground where shown on the plans, complete with vent, fill, and supply line to the burner, and an indicating gage of the remote type.

Card No. 24
Job No. ___

EXPANSION

___ COMPRESSION TANK: Furnish and install where shown on the plans _____ one _____ gallon compression expansion tank of copper bearing welded steel constructed and so certified to withstand a static air pressure of ___ 100 psi for a period of two hours without drop. This tank shall be similar and equal to those manufactured by the _____.

Card No. 25
Job No. ___

(instantaneous)

___ DOMESTIC HOT WATER HEATER: Furnish and install in the boiler one instantaneous coil type water heater having a capacity to raise _____ gpm of water from 50 ___ F to 150 ___ F. Connections to and from this heater will be made under another contract.

(indirect water heater)

___ DOMESTIC HOT WATER HEATER: Furnish and install adjacent to the boiler one tankless indirect hot water heater to operate by hot water steam in conjunction with a _____ gallon tank. The water connections are to be made to the tank by others. The tank heater is to have an immersion type thermostat to maintain a constant water temperature. The heater and tank are is to be located where shown on the plans. The heater shall have the capacity to heat ___ gpm from 50 ___ F to 150 ___ F with a boiler water temperature of ___ F steam pressure of ___ psig.

"OPEN FOR DISCUSSION"

Recirculate Air from Industrial Exhaust Systems?

ALLEN D. BRANDT raises some very pertinent questions in his article, Should Air Be Recirculated from Industrial Exhaust Systems? in the August issue. It seems to me that there is no argument in favor of recirculation as compared with straight exhaust and supply ventilation if it is economically practical to use 100 per cent outside air and if the outside air being supplied is of good quality.

Our criticism of using outside air entirely for supplying industrial exhaust systems is that ordinary outside air in an industrial neighborhood which has been contaminated with exhaust fumes and dust may be of poor quality and may give you an industrial health hazard when you think you are using "God-given fresh air." When you see the junk that comes out on the ordinary filter and see the corrosion that takes place in the ordinary air washer you wonder that the human body can stand so much!

In the struggle for survival, man evolved on air which had dust but not these chemical contaminants that we get in the industrial areas. So when we talk about outside air for ventilation we must be sure that it is fit for breathing. In many cases you can justify recirculation and really good air cleaning of the recirculated air in order to get supply air fit to use.

We follow here the custom of engineering society meetings in allowing a period for questions, answers, and comment following presentation of a paper. You are invited to contribute your views on published articles, other matters of importance. Address the Editor, Heating, Piping & Air Conditioning, 6 N. Michigan Avenue, Chicago 2, Illinois

What Happens to the Neighbors?

The other point that Dr. Brandt neglects is, what happens to the neighbors? If you do throw away your exhaust air you will certainly belittle the importance of cleaning it for the general benefit of the neighborhood. Legislation might require certain types of contaminants to be removed from air before it is thrown away, but what happens at night? In discussing smoke control we all know that boilers are blown down at night because you can't see the smoke. I can imagine that any industrial air cleaning system might be used only at the times you expected somebody to see what was going on and the rest of the time it would be shut down for "economic reasons." If you are going to re-use your own air, you will clean it and clean it good—I betcha!

Use Warning Devices

I do not subscribe to the possibility that air cleaning equipment will break down, become inoperative and therefore should not be depended upon. Our entire industrial life is based on using equipment that will run. Certainly if it gets out of order there can be some warning device installed so that you know it. The simplest type of refrigeration machine, fan, boiler, or other heating, ventilating, or air conditioning equipment must be depended upon for continuous operation. Instead of suggesting that we shouldn't use it because it might "fall on its face," the emphasis we should use is that of dependable equipment and dependable controls with suitable warnings.

Should Air Be Recirculated from Industrial Exhaust Systems?

Industrial ventilation is going to come up fast because the manufacturer will find that it pays to supply *good* air. Those of us who have the opportunity to work with industrial air must accept the responsibility that goes with this opportunity. There are many times when recirculated air should be planned on, rather than 100 per cent outside air for ventilation.—LESTER T. AVERY, president, Avery Engineering Co.

Heating, Piping & Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

Use of Climatological Data in HEATING and COOLING DESIGN

By H. E. Landsberg*, Washington, D.C.

SUMMARY—In all cases where climatological information is used for engineering purposes it is not the average that counts, but the frequency distribution of climatic elements.

Methods are suggested for applying corrections for local conditions to obtain best design values. By such corrections advantage may be taken of long records obtained at U.S. Weather Bureau stations to obtain the proper design conditions for locations within a radius of 100 miles.

THE INVENTION of the house is one of the greatest achievements of mankind. The main purpose of a house is to afford protection against the climate. The ideal house should be designed to reduce the climatic fluctuations to a minimum and keep inside conditions always within the zone of comfort. For most persons, who have to live on small incomes, this ideal has to be achieved with a minimum of initial capital and lowest possible operating expenses.

The variation of climate from place to place is, unfortunately, of such nature that uniform standards for construction cannot be used. The design values have to be adapted to the climatic conditions actually encountered. If this is not done, houses may be constructed with an excessive safety factor. This leads to unnecessary high initial costs. On the other hand, if the original structure is inadequate for the exigencies of climate, the operating costs will be excessive.

Accurate knowledge about the climate of the locality where the house is to be constructed is therefore an essential prerequisite for arriving at the best engineering solution.

*Committee on Geophysical Sciences, The Joint Research and Development Board.

Climatological Factors

There are manifold basic climatological data that should be considered in the planning for houses. The most important factors in that connection are: air temperature and derivatives, such as degree days; soil temperature; humidity; precipitation, including information on snow loads; wind direction and speed, including gustiness factors. In many cases combinations of these simple climatic elements are needed and this point will be referred to again.

The basic data are available for a great many locations in this country. Year after year the observations are faithfully collected by many professional and amateur weather observers. Most of their efforts are directed toward current use of their observations for airway protection, daily weather forecasts, and crop estimates. Then the data are filed away. Most of the stations furnish average values of the observations, summarized by month, year, and period of record. These averages, when they are based on data accumulated over many years, often acquire the mystic aura of so-called *normals*. In many cases they are very far from being the *usual* condition, a connotation generally associated with the term *normal*. The designer of houses should not be fooled by the climatic *normals*. They are nothing but an arithmetic mean and hence convey only a very limited amount of information about the climate of a place. They permit a simple comparison between the climates of two places. This is often satisfactory for general geographical purposes but for building construction such information is entirely inadequate.

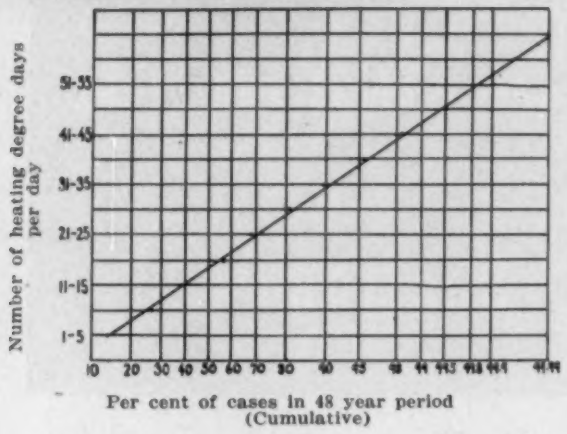


Fig. 1—Cumulative frequencies of heating degree day values, by steps, at Washington, D.C., on probability scale

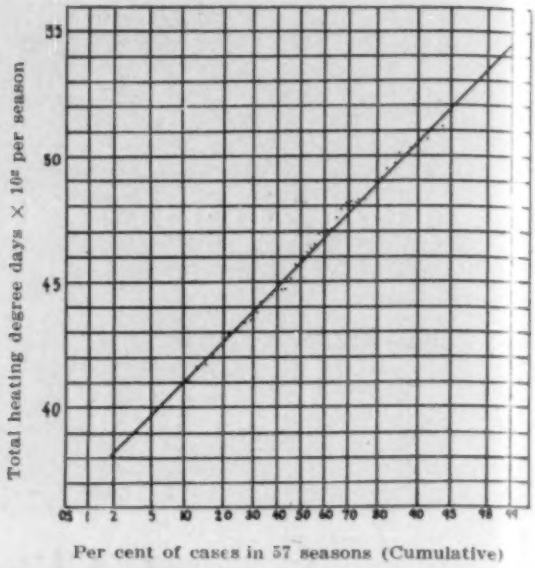


Fig. 2—Frequency array of seasonal heating degree days 1889-1945 at Washington, D.C., on probability scale

Importance of Frequency Distribution

In all cases where climatologic information is to be used for engineering purposes it is *not* the average that counts but the frequency distribution of climatic elements. The designer has to know the conditions which are most frequently encountered as well as the spread of values for which the house is supposed to compensate. Cooperative efforts between the ASHVE and the U. S. Weather Bureau have initiated the preparation of frequency tables of climatic elements covering five years of hourly observations at a little over 100 stations for the following elements: dry bulb, wet bulb, dew point temperatures; coincident values of dry bulb and wet bulb temperatures; coincident values of wind speeds and temperatures (completed for only one city to date). Such climatic tables, when completed, will offer the opportunity to place climatic design values on a *calculated risk* basis.

The purpose of the design task at hand indicates to the engineer the risk he can afford to take. For example, the heating plant of an ordinary house, generally, does not have to be designed to cover every contingency of low temperatures. In the past some design temperatures have been based on the lowest temperature on record. That is usually a value that may be encountered just once in 50 years. Most home owners are generally satisfied if their houses can be kept uniformly heated to a pre-selected comfortable temperature, say 99 per cent of the days. It may be quite acceptable if, during a few exceptionally cold nights, the house temperature gets a few degrees below the standard. Owners may have to restrict their heating on such days to fewer rooms or employ auxiliary heaters. Most home owners are willing to face such conditions for a few days every three or four winters in return for reduced installation and operating costs.

Design temperatures are, of course, a theme around which endless arguments can be spun. An example may illustrate how common-sense solutions can be arrived at. The discussion will be based on heating degree day values observed at Washington, D. C. Table 1 shows the number of degree days by steps in 48 heating seasons, 1898-99 to 1945-46, based on 65 F and the observed daily mean temperature [½ (max — min)] at the U. S. Weather Bureau Office in the city. Out of the 17,531 days in the period 38 per cent had no degree days. Of the remainder of 10,872 days, 13.3 per cent had only 1 to 5 degree days, an amount that most likely did not require heating of the average house.

Table 1—Heating Degree Days (base 65 F) Washington, D.C., 1898-99 to 1945-46

(Number of cases within specified intervals)

Interval degree days	Number of cases	Interval degree days	Number of cases
1-5	1445	36-40	619
6-10	1389	41-45	318
11-15	1387	46-50	138
16-20	1460	51-55	44
21-25	1630	56-60	7
26-30	1439	61-65	5
31-35	989	66-70	2

Total number of days with mean below 65 F	10,872
Total number of days with mean above 65 F	6,659
Total number of days during period	17,531

The design temperature generally in use for Washington, D.C., is 0 F. For a day with a mean temperature of 0 F the degree day value is 65. Such a high degree day value was encountered only three times during the 48-year period, *i.e.*, less than 3/100 of one per cent of the cases. There were, in fact, only 14 days in the period with degree days in excess of 55. It would seem entirely adequate to have a design temperature of 10 F for Washington and still be able to take care of 99.9 per cent of all cases.

Probability Curves

In this connection it may be interesting to note that the cumulative frequencies of the daily values of heating degree days at Washington essentially plot as a straight line on logarithmic probability coordinates (Fig. 1). Similarly, the seasonal totals of degree days at Washington are, statistically speaking, essentially normally distributed, as shown in Fig. 2. Even though only 57 seasonal values are

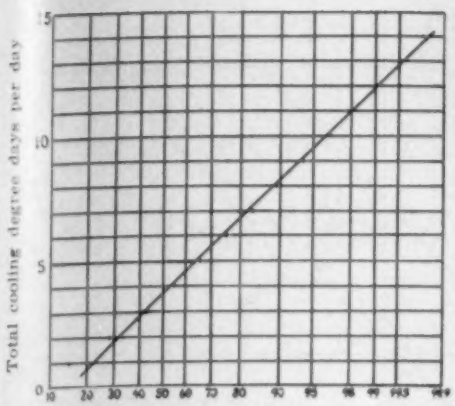


Fig. 3—Cumulative frequencies of cooling degree day values, by steps, at Washington, D. C., on probability scale

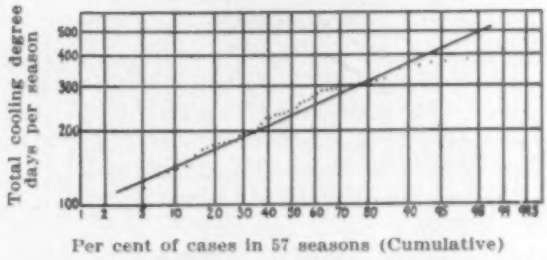


Fig. 4—Frequency array of seasonal cooling degree day values 1889-1945 at Washington, D.C., on logarithmic probability scale

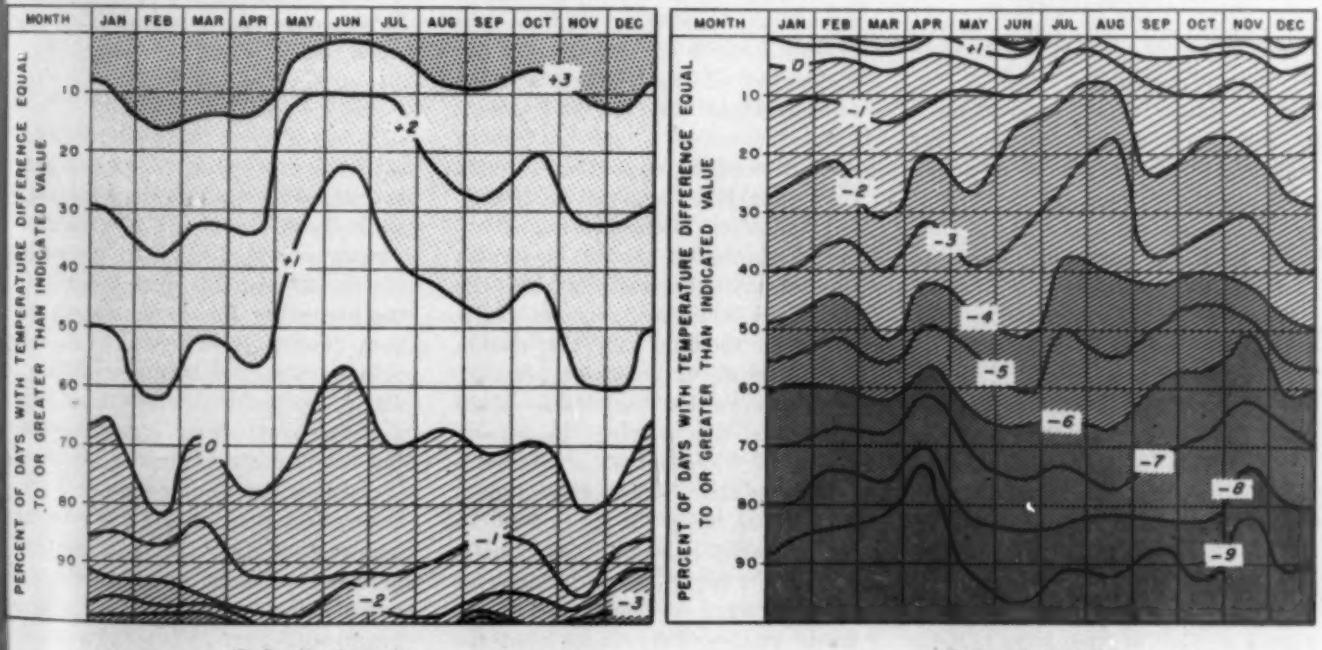
available (1889-1945), all but the extremely high and low values arrange themselves closely around a straight line on probability coordinates. Graphs such as these easily permit selection of any desired limits of values. For example, 95 per cent of the data lie between 3600 and 5300 annual degree days. Probability curves of this type are useful for both design and operation of central heating plants.

Daily values of *cooling* degree days (*base 75 F* and daily mean temperatures), 1898-1945, at Washington, D. C., also show a straight line probability curve (Fig. 3). The *seasonal* values of *cooling* degree days at Washington, D. C., however, are not normally distributed. Even when plotted on logarithmic probability coordinates some deviation from a logarithmically normal distribution is noted, although a fair fit of the values to a straight line is obtained (Fig. 4). Again, some planning value is inherent in this type of presentation of climatic data. At any rate, they are space saving compared to tables and are ordinarily sufficiently accurate to read off various significance levels.

Temperature data from the Washington, D. C., area are also useful to illustrate another point. The data derived from the climatic observations of a station can, strictly speaking, be applied only to problems arising in the immediate environment of the station. The more heterogeneous the terrain surrounding a station is, the greater the need for the label *not transferable* on the data sheets. In the past, construction engineers have occasionally used conveniently available climatic data from one station for places 50 or 100 miles distant. Even interpolation on maps, which show lines of equal design values, is acceptable only for the roughest of estimates.

Limitations in Use of Data

In hilly or mountainous country micro-climatic differences within a few miles are as large as macro-climatic changes over several degrees of latitude. This is immediately obvious from the two diagrams of Fig. 5. These show the frequency of differences of daily maximum and minimum temperatures be-



(Daily Maximum) (Daily Minimum)

Fig. 5—Frequency of occurrence of temperature differences throughout the year between Weather Bureau Office, Washington, D.C., and suburban station at Sleepy Hollow, Va., 1942-1944.
(Diagram on left shows differences of daily maximum temperatures; diagram on right shows differences of daily minimum temperatures. Graph was obtained through the courtesy of R. T. Zoch, U.S. Weather Bureau.)

tween Washington city observations and those of a suburban station seven miles distant (Sleepy Hollow, Va.). The simultaneous records cover three years. The diagram on the left shows that the differences between the daily maxima at the two stations are not great. Sleepy Hollow has a tendency toward somewhat higher maxima. Yet in case of the minimum temperatures the difference is remarkable. With a few exceptions Sleepy Hollow shows lower minima than the city. In over 50 per cent of the cases at all seasons this difference exceeds 4 deg and in about 20 per cent of the cases the difference is 8 deg or more.

Similar conditions can be found near other cities and this should serve as a warning that climatological data always require interpretation if they are to be used for locations other than the observation place. In many cases, airport records give more realistic values for suburban areas than city records. Most disconcerting, however, are cases where data from two different localities in the same metropolitan area are mixed together. Sometimes climatic records were started in a downtown area and later were transferred to an airport 10 or more miles distant. Such inhomogeneous records should not be used for design purposes.

Fortunately most of the time it is not very difficult to discover whether or not a record is homogeneous and to homogenize it if it is heterogeneous. The only requirement is that a homogeneous record exists at a reasonably close locality. Generally a station within a hundred mile radius will be satisfactory as a reference point. The following example is illustrative for more than one reason.

Only 17 miles from Washington, D.C., is the suburban community of Cheltenham, Md. A comparison of degree day values for the Cheltenham station and the city station in Washington was made. Fig. 6 shows a plot of the simultaneous seasonal values for the two stations from 1900-01 to 1944-45. It is immediately obvious that the data arrange themselves along two regression lines. All the values scattered around the upper line of the graph resulted from Cheltenham observations since 1935-36. Evidently a break in the continuity of observations had occurred at that time. Before that season Cheltenham degree day values were on an average 75 degree days per season above the Washington values. In the last ten seasons of the record the difference rises to an average of about 450 degree days. It is a simple task to adjust the earlier record to the present locality and exposure of the station by adding 375 degree days to the values observed at Cheltenham. Instead of a ten year record at that location, reasonably reliable values for 45 seasons can be used.

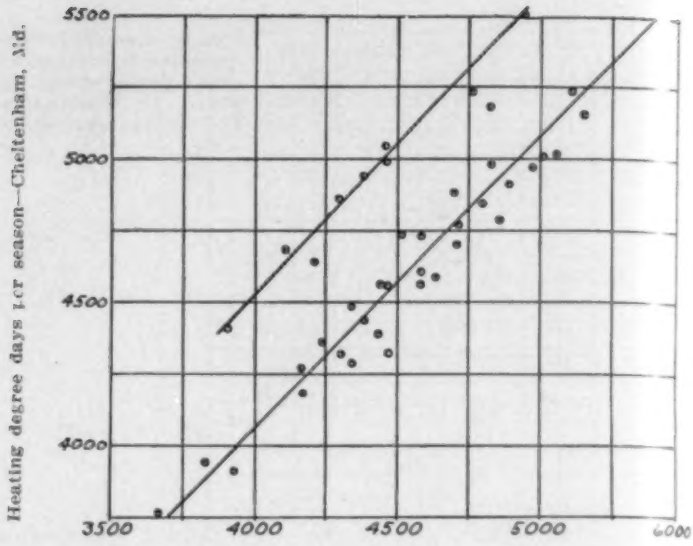


Fig. 6—Regression between seasonal degree day values at Washington, D. C., and suburban Cheltenham, Md., 1900-01 to 1944-45

(Lower line represents data prior to 1935-36, upper line those after that season. Inhomogeneity of record is introduced by change at Cheltenham station.)

In addition to the process of homogenization the record illustrates the type of changes that are encountered when stations are shifted, when shelters and instruments are replaced, or exposures altered. It also shows that degree day values (and the temperature values on which they are based) of a metropolitan center cannot immediately be used as basis for design values for a nearby suburban community. Finally, it shows that, because of the constancy of differences of climatic values, there is no need for very long records at such a suburban locality. Sometimes only a year or two of records will enable the climatologist to derive averages and frequency distributions for that community by deducing the values from a long record in the vicinity. At times the construction engineer can secure climatic data badly needed for design purposes for a major structure, such as a hospital, if, at the same time the surveyor starts his work on the site, a climatic station is established. Many a time, long before final construction work starts, sufficient climatic observations may have been secured to take the guess work out of the design job.

Air Motion and Radiation

It has already been briefly pointed out that the climatic data as they are collected by weather stations, while helpful, are not always completely satisfactory to fill the needs of the engineer for design data. In the preceding discussion degree day data figured prominently. Yet it is obvious that the temperature or a direct derivative therefrom is only a rather superficial index describing the heating or cooling power of the atmospheric environment. From theoretical reasoning alone one can deduce that in addition to the temperature at least another element, namely, the air motion, will play a prominent part in the process of heat transfer. In a similar problem, the protection of the human body from excessive heat loss, this

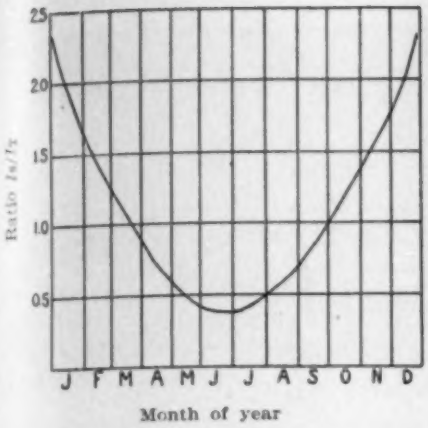


Fig. 7—Annual course of ratio of radiation intensity measured on vertical surface exposed to the south (I_S) and intensity on horizontal surface (I_T), at Blue Hill Observatory near Boston, Mass.

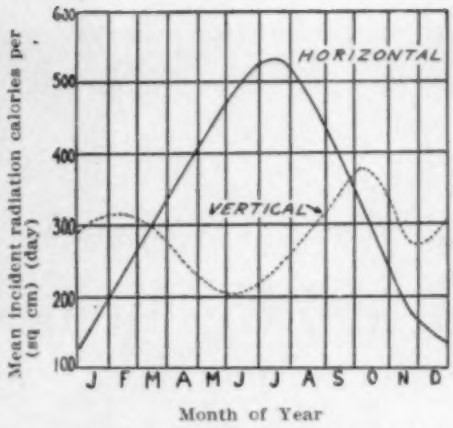


Fig. 8—Intensity of mean incident radiation on horizontal surface and on vertical surface facing south

Solid curve, average annual course of radiation intensity on a horizontal surface, dashed curve, annual variation of radiation intensity on vertical surface exposed toward south (calculated from values underlying the solid curve and those represented in Fig. 7), from observations at Blue Hill Observatory near Boston, Mass.

problem has long ago been solved by using a combination of temperature and wind speed. The cooling power of the air on a body of 98 F temperature has been established by empirical formulas and attempts have been made to establish that factor even directly by observations by means of Hill's Kata-thermometer or electrical instruments based on the basic principle of the Kata-thermometer. There is no good reason why similar formulas and equipment cannot be obtained for inanimate structures.

In the same problems of ascertaining the cooling power of the environment on the human body the influence of another equally obvious additional element was soon discovered; the heat gain and loss by radiation. Air temperature readings taken by carefully shielded thermometers reflect radiation conditions only remotely. Many structures, however, are fully exposed to all radiative influences. Most powerful among them is the direct solar radiation. This element should enter into all considerations of heat exchange between houses and their environment. Several factors have militated against this postulate. First of all, there are only a few localities from which regular series of radiation observations are available. Secondly, these observations are not immediately applicable to the design problems because nearly all of these observations measure the radiation incident on a horizontal surface. Only by very tedious processes can the radiation on vertical surfaces exposed in various azimuths (walls) or slanting surfaces (roofs) be calculated from the reported values. Even then certain doubts affect the calculated values because of selective cloudiness effects.

Recently, a series of measurements of radiation intensities on vertical surfaces has been reported by I. F. Hand.[1] While these cover data from one locality only for a period of about 15 months, they open nevertheless new avenues of approach to radiation design values. The observations were gathered at the Blue Hill Observatory near Boston, Mass. From Hand's tables a few graphs have been derived that may illustrate the usefulness of the information. Special emphasis is given to the values obtained from a pyrheliometer recording the radiation on a vertical surface facing south. Fig. 7 shows the annual variation of the ratio I_S/I_T, where I_S is the incident radiation on the vertical surface facing south and I_T the conventionally measured radiation on the horizontal surface. The curve was obtained from weekly values of the radiation totals and was smoothly drawn through the points to compensate for fluctuations that may be introduced by the shortness of the period of record.

It is interesting to note that in December the vertical surface facing south receives over twice the total radiation received on a horizontal surface. The importance of this for supplemental heat for a house with picture window to the south needs no emphasis. On the other hand, in midsummer the south wall receives less than half the radiation received on a horizontal surface. The specific values shown in Fig. 7 apply strictly only to the Boston area. Elsewhere different latitude and cloudiness conditions will result in other figures. Yet the same order of magnitude of the ratio will obtain in most of the area of the northeastern Atlantic coastal area.

There is also good reason to believe that the ratios shown reflect the annual variation well even though the period of record is short. This provides an opportunity to translate the long record of radiation intensities on a horizontal surface at the Blue Hill Observatory into intensities on a vertical surface facing south. Fig. 8 shows as a solid curve the mean radiation values on a horizontal surface as obtained from 13 years of observations. If that curve is combined with the ratios discussed above, the dashed curve results. This last curve then represents the mean intensities of radiation on a surface facing south. Systematic observations of this type at other localities should be instituted. They would serve to take the guess work out of designs for use of solar heating.

Evaporative Cooling

As modern approaches to design increase, more and better use for climatological information can be found. One more problem in this connection will be mentioned; the use of free-air evaporation for cooling. The evaporative power of the atmosphere as a climatic element has been given insufficient attention in the past. In this case as well as in other design problems for housing construction cooperative efforts between engineers and climatologists can find the answers that will lead to houses optimally adapted to the climatic environment.

[1]Solar Energy Received on a Vertical Surface Facing South, by I. F. Hand, (Bulletin of the *American Meteorological Society*, Vol. 27, 1946, p. 416).

JOURNAL SECTION

Elected to Life Membership in ASHVE

C. R. Ammerman
Indianapolis, Ind.

C. Gottwald
Cleveland, Ohio

During 1947, the following members were honored by election to the ranks of Life Members of the American Society of Heating and Ventilating Engineers: C. R. Ammerman, president, Ammerman, Davis and Stout, Inc., Indianapolis, Ind.; G. W. Davies, manager, F. W. Davies and Co., Dunedin, New Zealand; C. Gottwald, president, The Ric-wiL Co., Cleveland, Ohio; Lloyd Howell, engineer, Howell Engineers, Houston, Tex.; C. H. Mosher, manufacturers' representative, Buffalo, N. Y.; Lee Nusbaum, owner, Pennsylvania Engineering Co., Philadelphia, Pa.; H. L. Roberts, heating engineer and contractor, Philadelphia, Pa.; M. B. Shea, retired, Wayne, Pa.; and Alf Tjersland, Oslo, Norway.

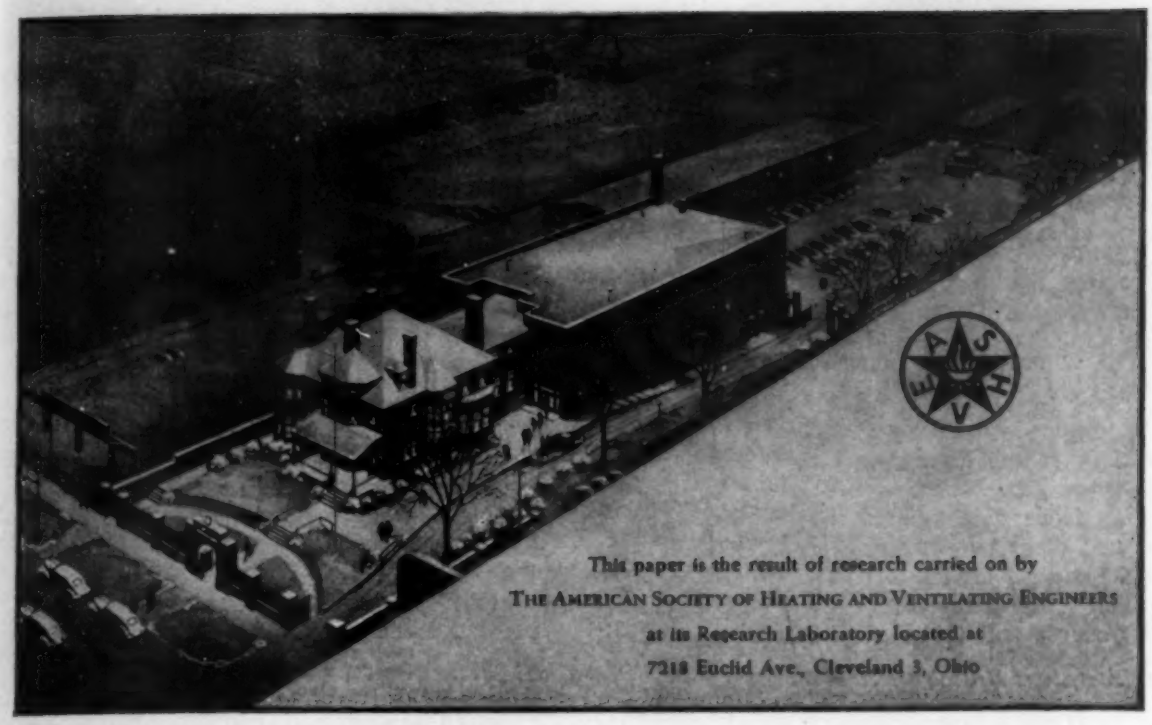
Lloyd Howell
Houston, Tex.

Lee Nusbaum
Philadelphia, Pa.

H. L. Roberts
Philadelphia, Pa.

M. B. Shea
Wayne, Pa.

Alf Tjersland
Oslo, Norway


This paper is the result of research carried on by
THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
at its Research Laboratory located at
7218 Euclid Ave., Cleveland 3, Ohio

Thermal Properties of Building Materials†

By H. B. Nottage*, Cleveland, Ohio

SUMMARY—This paper presents data from ASHVE RESEARCH BULLETIN, Vol. 53, No. 2 (now on press), which summarizes results of a search of the literature for ready-reference data on thermal conductivity, density and unit heat capacity of common building materials. By means of charts included an estimate may be made of: thermal conductivity; thermal diffusivity; or of the product (thermal conductivity) × (density) × (unit heat capacity).

Introduction

Need for Data

PRACTICAL advances made in the treatment of the *periodic* flow of heat through building walls and roofs brought about recognition of the present need for a compilation of thermo-physical data. The study of periodic heat flow is of special value in improving the accuracy of summer cooling-load calculations.

The nature of the *periodic* heat flow problem has been developed in recent papers presented before the Society (1, 2, 3, 4).[1] Successful application of the method of calculation requires: (*a*) Accurate data on thermo-physical properties; (*b*) data on *other properties* besides the thermal conductivity in steady-state heat flow calculations.

The properties involved are:

1. Fundamental Properties: (a) Thermal conductivity; (b) Density; and (c) Unit heat capacity.[2]

2. Derived Properties: (a) The product (Thermal Conductivity) x (Density) x (Unit Heat Capacity); (b) Thermal resistance per inch of material thickness; and (c) Thermal diffusivity.

Introduction of the *density* and the *unit heat capacity* into the calculations is necessary because in *periodic* heat flow the all-important *storage of heat* in the material must be considered. The quantity of heat stored in a unit volume of the material is *variable* with time and position in the roof or wall. Because this storage is variable, the maximum contribution to the cooling load in an interior space occurs at some time of the day subsequent to the occurrence of the maximum rate of heat flow into the outer surface. These conditions are all controlled by the properties of the materials involved.

The derived properties have been considered for the purpose of expediting practical calculations. The product kc_p or (thermal conductivity) × (density) × (unit heat capacity), is employed as a factor in the design charts of Mackey and Wright (3). The thermal resistance is also employed in these charts and is useful also for steady-state heat transfer calculations. The thermal

†Digest of data from ASHVE RESEARCH BULLETIN, Vol. 53, No. 2, Thermal Properties of Building Materials. In this paper Fig. Nos. corresponding to those in the Bulletin are as follows: A = 5; B = 8; C = 9; D = 10.

*Research Associate, ASHVE Research Laboratory. Member of ASHVE.

[1]Numerals in parentheses refer to references.

Presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Coronado, Calif., June 1947.

[2]Unit heat capacity and specific heat are numerically identical, but the former has the dimensions of (Btu)/(lb) (F deg) while the latter is a dimensionless ratio. It is the *unit heat capacity* which, properly speaking, is employed in the calculations. Further, in this type of study it is the unit heat capacity at constant pressure which is always used.

JOURNAL SECTION

diffusivity is of general utility in transient and periodic heat-flow analyses where temperatures and heat flow rates vary with time; its definition is:

$$\text{Thermal diffusivity} = \frac{\text{Thermal conductivity}}{(\text{Density}) \times (\text{Unit heat capacity})}$$

The first step in meeting the need for data of the nature suggested has been the collection of presently available data from the literature and other sources in order to make them available to the practicing engineer in the form of convenient curves and tables (5).

Scope of Literature Search

The study of the literature comprised a survey of all readily-available references such as texts, papers, handbooks, and the International Critical Tables. Some unpublished data also were obtained from engineering organizations in a position to supply pertinent information. Preference was given to the representation of well-known types of materials by a single entry indicating a range of magnitudes to be expected for the properties, rather than by the exhaustive listing of innumerable individual variations. Materials for which data were lacking on one of the fundamental properties were not included in the final tabulation.

One significant experience encountered during the literature search is deserving of general recognition. Initially it was expected that a certain amount of competitive judgment would be required between conflicting data. Yet no significant instance of this was found because thermo-physical properties have not been made the subject of sufficiently exhaustive fundamental studies.

Nature of Data Obtained

Building materials were divided into six classifications. A complete tabulation covering constituent materials of each classification and giving data for the six properties of interest has been made (5). Table 1 of this paper summarizes the scope of these complete tabulations for three of the properties in most common use.

Wood was found to be the only class of material for which adequate data were available to permit drawing of curves presenting the properties as functions of moisture content, temperature, and species. Fig. A is a sample of such curves.

Empirical Estimates of Properties

One very important result of the compilation of literature data has been the rough validation of an approximate basis for *estimating* the necessary thermo-physical properties where only the density may be

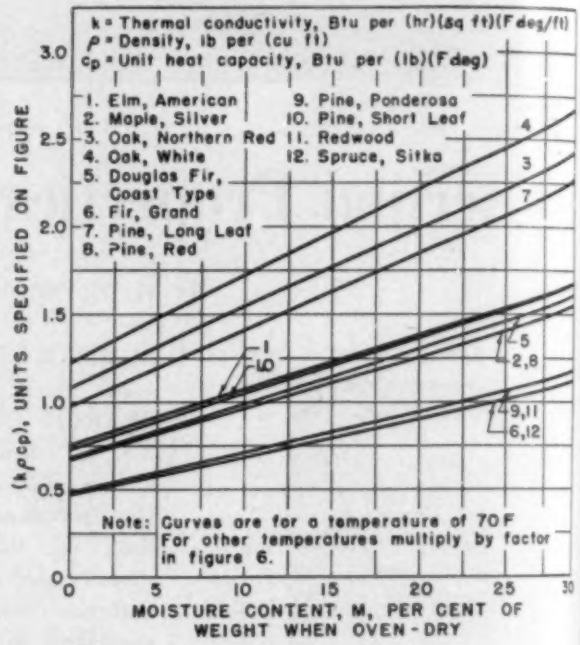

k = Thermal conductivity, Btu per (hr)(sq ft)(F deg/ft)
ρ = Density, lb per (cu ft)
cp = Unit heat capacity, Btu per (lb)(F deg)
1. Elm, American
2. Maple, Silver
3. Oak, Northern Red
4. Oak, White
5. Douglas Fir, Coast Type
6. Fir, Grand
7. Pine, Long Leaf
8. Pine, Red
9. Pine, Ponderosa
10. Pine, Short Leaf
11. Redwood
12. Spruce, Sitka
(kρcp), UNITS SPECIFIED ON FIGURE
MOISTURE CONTENT, M, PER CENT OF WEIGHT WHEN OVEN-DRY
Note: Curves are for a temperature of 70 F For other temperatures multiply by factor in figure 6.

Fig. A—Magnitudes of ($k\rho c_p$) for representative woods

Table 1—Scope of Tabulations in the Complete Bulletin (Ref. 5)

Material Classification	Number of Entries	Density, lb / Cu Ft		Thermal Resistance, (hr)(sq ft)(F deg/in.) / Btu		Product $(k\rho c_p)^a$, (Btu)² / (hr)(ft)⁴(F deg)²		Unit Heat Capacity, Btu / (Lb)(F deg)	
		Max	Min	Max	Min	Max	Min	Max	Min
Hard Woods	11	42.1	27.1	1.14	0.80	1.71	0.76	0.42	0.32
Soft Woods	16	37.2	7.3	3.03	0.87	1.38	0.079	0.42	0.32
Building and Insulating Boards and Insulating Materials	27	123.	3.9	4.6	0.37	5.5	0.013	0.39	0.18
Masonry Materials	11	172.	105.	0.35	0.044	72.	5.7	0.26	0.18
Structural Concrete, Plaster, and Mortar	14	145.	51.	0.63	0.072	37.	1.9	0.28	0.21
Glass	6	158.	152.	0.15	0.12	21.5	18.	0.22	0.20
Roofing Materials	16	172.	55.	1.8	0.10	25.	0.80	0.35	0.18

[a](thermal conductivity) x (density) x (unit heat capacity).
Note: Magnitudes indicated are for ordinary temperatures and moisture contents as far as the data are known.

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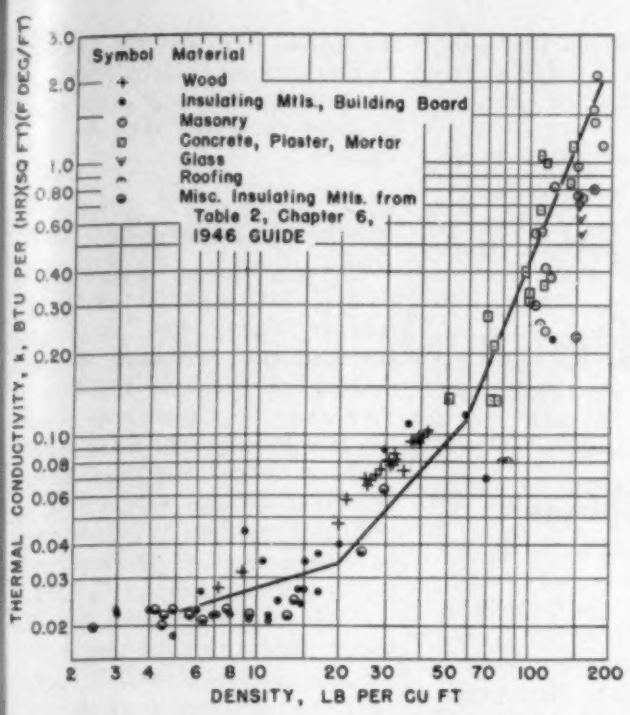

Symbol Material
+ Wood
• Insulating Mtls., Building Board
○ Masonry
□ Concrete, Plaster, Mortar
▽ Glass
△ Roofing
⊕ Misc. Insulating Mtls. from Table 2, Chapter 6, 1946 GUIDE
THERMAL CONDUCTIVITY, k, BTU PER (HR)(SQ FT)(F DEG/FT)
DENSITY, LB PER CU FT

Fig. B—Comparison between data from Bulletin (5) and empirical estimating equations for thermal conductivity

known. Mackey and Wright have suggested this procedure. Figs. B, C, and D show how the thermal conductivity, the product ($k\rho c_p$) and the thermal diffusivity for all materials listed in ASHVE RESEARCH BULLETIN, Vol. 53, No. 2, plot as functions of density. The lines in Figs. B, C, and D were obtained from the *equations* proposed by Mackey and Wright (3). This demonstration is offered as a practical guide for estimating purposes when test information is not available.

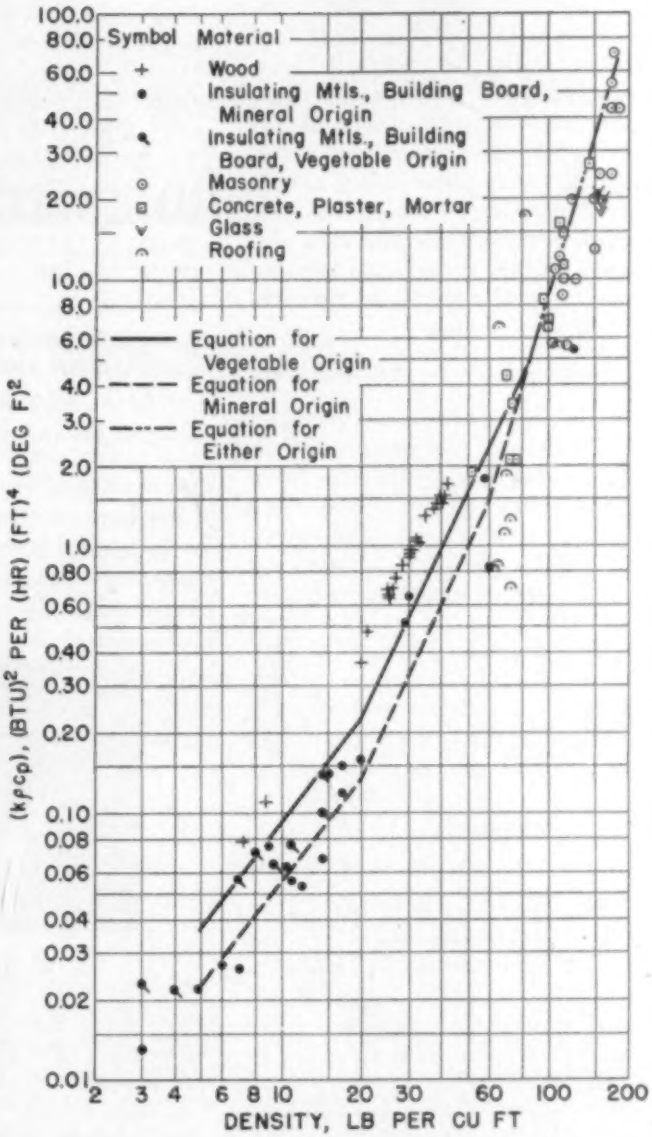
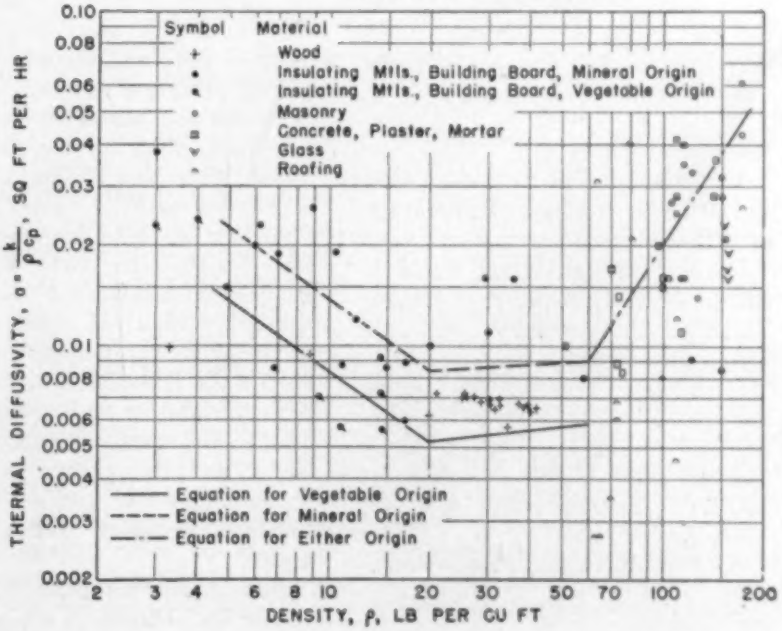


Fig. C—Comparison between data from Bulletin (5) and empirical estimating equations for ($k\rho c_p$)

Fig. D—Comparison between data from Bulletin (5) and empirical estimating equations for thermal diffusivity


Symbol Material
+ Wood
• Insulating Mtls., Building Board, Mineral Origin
Insulating Mtls., Building Board, Vegetable Origin
○ Masonry
□ Concrete, Plaster, Mortar
▽ Glass
△ Roofing
Equation for Vegetable Origin
Equation for Mineral Origin
Equation for Either Origin
THERMAL DIFFUSIVITY, α = k/ρcp, SQ FT PER HR
DENSITY, ρ, LB PER CU FT

Results Obtained from Literature Survey

The survey has shown that:

1. Data for wood and glass are in good order and generally satisfactory for present needs.
2. Data for building and insulating boards and insulating materials are in good order except for the lack of adequate information on the influence of moisture content.
3. Data on masonry materials, on concrete, plaster and mortar, and on roofing materials may be sufficient for most practical load estimates, but they could well be extended to give more adequate coverage to the influence of composition, temperature, and moisture content.

For the present it is concluded, in accord with the general state of load-estimating calculations, that the data summarized in ASHVE RESEARCH BULLETIN, Vol. 53, No. 2, should be an adequate basis for

practical work in periodic heat flow. *Design tables* for periodic heat-flow estimates can be prepared to minimize the detail required for periodic heat-flow calculations, much as the familiar tables now in THE GUIDE[3] serve for steady-state heat-flow estimates. The data discussed in this paper have been an essential preliminary to preparation of such tables.

Continuing Need for Further Data

It is important that emphasis be given to the *inadequacies* of the information now available. While it may serve present needs, many more systematic and fundamental data will be needed if heating and cooling load estimates are to become more exact. Increased recognition must be given to the important effects of moisture content, composition, and temperature upon thermo-physical properties. All data should also be obtained by standardized or approved experimental techniques.

Sponsorship and Acknowledgment

This study has been carried on under the sponsorship of the ASHVE Committee on Research with guidance by the Technical Advisory Committee on Cooling Load. Grateful acknowledgment is given to the cooperation of those individuals and organizations who supplied data not heretofore available in the published literature and thereby made this compilation more comprehensive and valuable.

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4. Periodic Heat Flow—Composite Walls or Roofs, by C. O. Mackey and L. T. Wright, Jr. (ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*, Vol. 18, June, 1946, pp. 107-110.)

5. The Thermal Properties of Building Materials, by H. B. Nottage. (ASHVE RESEARCH BULLETIN, Vol. 53, No. 2, 1947.)

[3]HEATING, VENTILATING, AIR CONDITIONING GUIDE 1947.

HUTCHINSON ACCEPTS CALIFORNIA APPOINTMENT

The appointment of F. W. Hutchinson as professor of mechanical engineering at the University of California, Berkeley, Calif., became effective September 1, 1947.

Professor Hutchinson is a graduate of California Institute of Technology and received his MS degree from the University of California in 1937, and served there as an associate professor of mechanical engineering. Since July 1, 1945, he has been at Purdue University, West Lafayette, Ind. He will continue on the Purdue staff as a consulting professor of mechanical engineering and will also remain as a consultant with Revere Copper & Brass, Inc., The Trane Co., and Libbey-Owens-Ford Glass Co.

F. W. Hutchinson

Elected an associate member of the Society in 1937, Professor Hutchinson advanced to full membership in 1942. At present he is a member of the Society's Council and of the Committee on Research. An authority on the subject of radiant panel heating, he has written many technical papers, presented at meetings and published in the Society's JOURNAL and TRANSACTIONS.

In addition to the ASHVE, Professor Hutchinson is a member of the *ASRE, IAS,* and the Tau Beta Pi Engineering Society, Sigma Xi, the *National Research Society*, and is listed in Who's Who in Engineering.

G. W. PENNEY APPOINTED PROFESSOR

The appointment of Gaylord W. Penney, Pittsburgh, Pa., an ASHVE member since 1938, as George Westinghouse Professor of Engineering at Carnegie Institute of Technology was announced recently. Mr. Penney will be a regular member of the electrical department faculty and will act as coordinator for some 50 students who have been awarded scholarships by the Westinghouse Electric Corp.

Graduating from Iowa State College in 1923 with a B.S. degree, Mr. Penney received his M.S. degree from the University of Pennsylvania in 1929. He has been employed by the Westinghouse Electric Corp. since 1923, when he took their student course. At the time of his appointment to the professorship, Mr. Penney was manager of the electrophysics division of the Westinghouse research laboratories. The holder of numerous patents, he is well known as the inventor of an electronic air cleaner and for the development of such other inventions as high-speed commutator constructions and various devices for cooling large turbines and dynamos with hydrogen.

In addition to his membership in the ASHVE, Mr. Penney is also a member of the *American Institute of Electrical Engineers*, Tau Beta Pi, Phi Kappa Phi, the *Pittsburgh Physical Society*, the *American Physical Society*, and the *American Association for the Advancement of Science.*

ALBRIGHT REORGANIZES

The firm of Albright, Lubin and Associates was dissolved by the partners, C. Barton Albright and Maurice Lubin, and is now operated under the title of C. Barton Albright, Engineer, 114 Liberty Street, New York, N. Y. As a consultant, Mr. Albright continues to specialize in the fields of industrial drying and curing, and industrial and commercial refrigeration. He has been an ASHVE member for a period of eight years and is a member of the New York Chapter.

A Method for Improving the Effective Temperature Index

By C. P. Yaglou*, Boston, Mass.

SUMMARY — Although recent studies in body heat regulation have not developed a more practical thermal index than effective temperature (ET) they have contributed much fundamental information that can be used to correct the ET index for humidity and radiation, as shown in this paper.

SINCE 1923, when the effective temperature (ET) was developed (1, 2),[1] many laboratory and field workers have found that this index over-estimates the influence of humidity on sensations of warmth and comfort at ordinary temperatures, and under-estimates the effect in very high temperatures which approach the limit of human tolerance to heat. The latest study by Rowley, Jordan and Snyder (3) adds to the evidence, and emphasizes the need for additional work that will increase the usefulness of ET to problems in comfort cooling and heating.

The writer, who had taken part in developing the ET, believes that the trouble is due to inadequate experimental technique and proposes a rational method for overcoming the disability in the light of newly developed principles which are discussed in this paper.

Re-appraisal of Technique of Determining the ET Index in the Light of Present Knowledge

Effective temperature was derived from *instantaneous* thermal impressions of subjects while passing back and forth from one conditioned room to another. In establishing combinations of temperature and humidity which felt equally warm, one of the rooms was kept at a high humidity with relatively low temperature, while the other room was adjusted to a lower humidity but higher temperature so as to make the two rooms feel alike in warmth. Two trained subjects recorded their sensory impressions (cooler, warmer, or no difference) immediately upon changing back and forth from one room to the other, without allowing time for physical or physiological adjustments. This was a matter of necessity rather than of choice, because thermal sensitivity diminished rapidly and after a short period the observers were unable to perceive large differences of humidity, or temperature differences of less than 2 to 3 deg between the two rooms, as contrasted with a sensitivity of 0.5 deg which was possible to obtain immediately upon changing from one room to the other. Judgment of warmth depended largely on sensations of the face and hands of clothed subjects and of the torso in subjects stripped to the waist. This was particularly true in experiments with high air velocities. The humidity effect obtained by this technique in ordinary temperatures was inordinately great and could not be verified by other investigators using different methods of approach.

Over-estimation of humidity effects, in the absence of sweat gland activity, can now be explained largely by adsorption and desorption phenomena and by failure to take adaptation (*acclimatization*) into account. In passing from a relatively dry atmosphere to a moist and cooler one, the exposed skin and clothing adsorbed moisture and the heat of adsorption imparted a transient sense of warmth. Upon returning to the drier room, excess moisture quickly evaporated, producing a transient cooling effect. The investigators, being unaware of these adsorption phenomena, had attributed the rapidly diminishing humidity effect largely to adaptation, and had proceeded on the assumption that all combinations of temperature and humidity which felt alike in warmth by first impression, would probably result in the same degree of adaptation after prolonged exposure.

This assumption is now known to be false. It is generally recognized that reactions of individuals on exposure to any given air condition are considerably modified by previous thermal experience and by the initial condition of the skin and clothing with regard to moisture.

Attempts to verify the seeming inordinate humidity effect by exposing subjects to more or less comfortable temperatures with different humidities were unsuccessful. In continuous exposures of 3 to 4 hours, the subjects readily adapted

*Professor, Industrial Hygiene, Harvard School of Public Health. Member of ASHVE.

[1]Numerals in parentheses refer to References.

Presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Coronado, Calif., June 1947.

themselves to the test conditions and showed no significant difference in rectal temperature, pulse rate, blood pressure, moisture loss, or impressions of comfort with different humidities.

On the other hand, in temperatures above 90 F when the subjects began to sweat, humidity became increasingly important in affecting the rate of evaporation of sweat and sensations of comfort and discomfort, and when the external temperature approached or exceeded that of the body's surface, humidity became the most important of all environmental factors. Physiological reactions in this high temperature field closely followed the ET index (4).

The present status of effective temperature is, therefore, questionable from the standpoint of humidity and humidity control for comfort heating or cooling. Its real value is in the warm and humid atmospheres where adsorption effects are insignificant because the skin becomes moist with perspiration. No other index can compete with effective temperature in that region except when radiation effects are important.

Mean Skin Temperature As an Index of Warmth

Although recent studies in body heat regulation have failed to develop a more practical thermal index than ET, they have contributed much fundamental information which can be utilized for improving the ET. One of the most significant and consistent findings, notably by Hardy and DuBois (5), and by Gagge, et al (6), is the existence of a close relationship between mean skin temperature and comfort in air conditions which lie below the zone of evaporative cooling, *i.e.*, when persons are not sweating.

Yaglou and Messer (7) have verified the validity of skin temperature measurements over a wide range of practical conditions summarized in Table 1. It can be seen that men and women were comfortable, in winter or summer, when their mean skin temperature averaged between 91.0 and 93.0 F, regardless of environmental temperature (30 to 82 F) when they were suitably dressed in clothing which weighed from a minimum of 0.1 lb at a temperature of 82 F to a maximum of 18.3 lb at 30 F, excluding weight of shoes.

The normal mean skin and clothing surface temperatures under ordinary winter and summer conditions are shown in Fig. 1. Barring emotional disturbances, mean skin temperature—a weighted average of 17 readings computed by the method of Hardy and DuBois (8)—appears to be a fairly sensitive index of warmth in temperatures under 82 F, or when persons are not sweating. When perspiration sets in, the skin temperature curve begins to flatten out (see Fig. 1) owing to cooling by evaporation of sweat. Beyond this point skin temperature rises very slowly and cannot, therefore, be taken as an accurate index of the degree of warmth or of discomfort experienced.

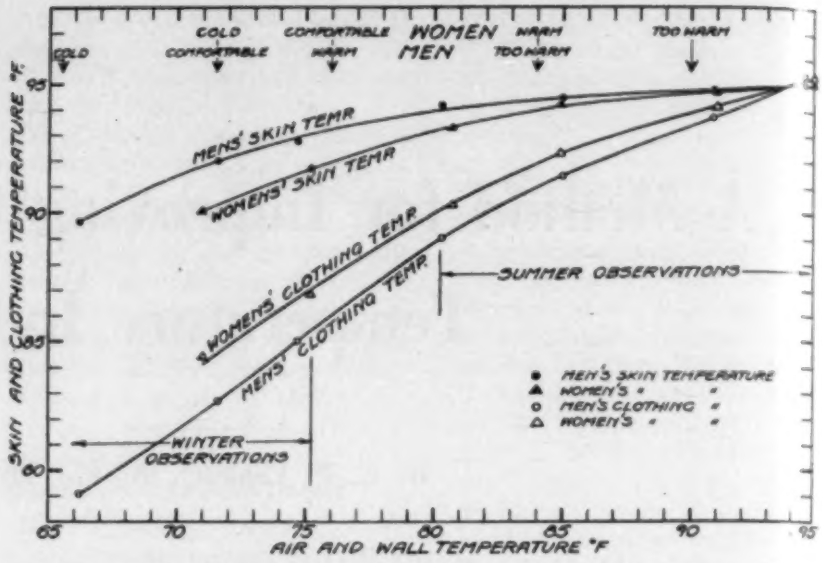

Fig. 1—Normal mean skin and clothing temperatures in relation to environmental temperature. Humidity natural; air movement 20-30 fpm

Skin temperature also fails as an index of warmth on exposure to sudden temperature changes while the skin temperature is rapidly changing, or during heavy muscular work when the skin temperature usually drops owing to diversion of blood to the active muscles.

Despite these limitations, mean skin temperature is the best objective index now available for studying the effects of thermal factors affecting comfort in resting persons. In fact, the skin constitutes the primary thermostat of the body. Its temperature reflects the effects of many factors, physical and physiological. On the interior it is affected by metabolic rate, blood circulation, nervous reflexes, body posture, etc., while on the exterior it is affected by clothing, air temperature, humidity, air movement, radiation, etc. Any factor affecting the rate of heat loss from the skin exerts its influence through a change of skin temperature.

Table 1—Mean Skin Temperature Under Comfortable Air Conditions With Various Amounts of Clothing
(Subjects at rest. Air Movement 20-30 fpm)

	Clothing worn (in season)	Clothing weight excluding shoes lb	Comfortable Air Conditions F	Comfortable Air Conditions Relative Humidity %	Comfortable Air Conditions ET	Mean body temp. Skin F	Mean body temp. Clothing F	Number of Persons
MEN	Shorts only	0.1	82	54	76	92.7	...	6
MEN	Summer clothes	3.0	76	52	71	93.2	86.1	17
MEN	Winter indoor clothes.	6.4	71	24	65	92.3	82.6	18
MEN	Winter outdoor clothes	14.5	55	45	54	91.8	67.6	2
MEN	Arctic p.le clothing....	18.3	30	78	30	90.7	...	3
WOMEN	Shorts and brassiere..	0.2	83	48	76	92.3	92.1	7
WOMEN	Summer clothes	0.7	80	55	74	92.7	90.3	23
WOMEN	Winter indoor clothes.	1.5	76	34	69	91.9	87.5	22

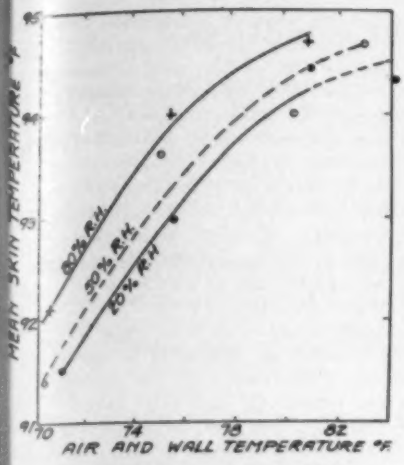

Fig. 2—Influence of humidity on mean skin temperature at various air temperatures. Air movement 20-30 fpm

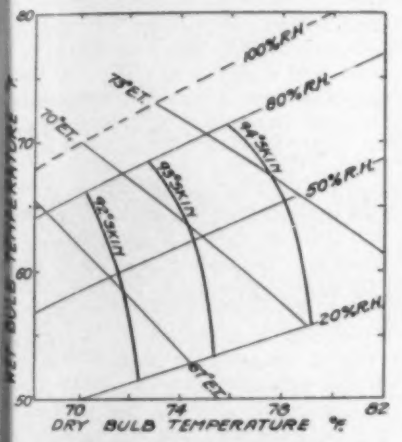

Fig. 3—Lines of equal mean skin temperature in relation to ET and to dry and wet bulb temperatures. Air movement 20-30 fpm

How to Correct the ET Index

It is evident from the foregoing that if ET were an accurate index of warmth it would closely follow the mean skin temperature; in other words, the ET lines as drawn on a psychrometric chart would also be lines of equal mean skin temperature, at least under thermal conditions which induce no sensible perspiration. On the other hand, should the humidity have no effect on warmth, the lines of equal skin temperature should run parallel to the dry bulb lines. Any departure of constant skin temperature lines from those of the dry bulb would be due to humidity if all other factors were kept unaltered.

An exploratory study was made in a conditioned room to measure skin temperatures at approximately 20, 50 and 80 per cent relative humidity, with temperatures between 70 F and 85 F. Two young men were exposed to these conditions for three hours before making final observations. The men wore customary indoor winter clothing weighing on the average 5.3 lb, excluding weight of shoes. Skin temperatures were measured by thermocouples on 17 areas under the clothing, and by a radiation thermopile on 6 exposed areas of the head and hands. Mean skin temperatures were computed by weighting the readings with Du Bois' area factors (8). The results are shown in Figs. 2 and 3.

Referring to Fig. 3, humidity appears to affect skin temperature measurably, but the effect is less than half of that indicated by the ET index. For instance, at 70 deg ET an increase of humidity from 20 to 80 per cent is equivalent to a decrease of nearly 3 F deg in air temperature on the basis of skin temperature, as against a decrease of 7 F deg indicated by ET.

Influence of humidities of less than 50 per cent on skin temperature appears to be negligible; the subjects themselves were unconscious of any definite humidity sensations in this region after the entry contrast wore off. With 80 per cent relative humidity, on the other hand, there was no difficulty in perceiving the high humidity and, when questioned, the subjects expressed preference for a lower humidity, although the objection was not great.

On the strength of this exploratory evidence it seems feasible to correct the ET index for humidity, and probably for radiation also, by substituting lines of constant skin temperature for the present ET lines, as shown in Fig. 3. Final results should be established by a more thorough study, using a greater number of subjects and covering a much wider range of temperature. It is important that subjects, as well as technique of measuring skin temperatures, once standardized, be kept unchanged throughout the study.

Summary

1. Effective temperature is shown to over-estimate greatly the influence of humidity in the range of temperatures met with in comfort heating and cooling.

2. The disability is attributed to adsorption and adaptation phenomena, which had been overlooked in the development of this index.

3. A rational method is proposed for correcting the index on the basis of mean skin temperature which is now known to be the best objective index of comfort.

4. It is recommended that the Society's Research Laboratory make a comprehensive study of the problem with a view toward settling once and for all this important limitation of effective temperature.

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DISCUSSION

C. E. A. WINSLOW, New Haven, Conn. (WRITTEN): The Society is to be congratulated on the admirable paper by Professor Yaglou. Many of us have been conscious for some time, of the fact that the present Comfort Chart does not reflect the true effects of humidity in the Comfort Zone. It is also quite clear, as Professor Yaglou has pointed out, that in this area skin temperature is the best measure of comfort. By a simple and direct experimental procedure he has, in this brief contribution, cut right into the heart of the problem and effectively solved it.

The investigators at our Research Laboratory in the early days in Pittsburgh, did a magnificent piece of work, but the progress of physiological knowledge since that time has now given us far more effective approaches to the problem. It is not a reproach to the pioneers but a tribute to their vision that, in the light of new knowledge, their work should be revised and brought up to date.

Skin Temperatures Vary with Sexes

JAMES D. HARDY, M. D., New York, N. Y. (WRITTEN): Professor Yaglou's proposal to use the average skin temperature as an objective index of comfort represents a real step forward in the rational treatment of the important practical problem of comfort. It is also of importance that Professor Yaglou has included women in his studies. It might be desirable to include older people (age 60 years or more) as they will probably constitute an increasing proportion of our population to whom air conditioning will be important. I should like to point out in this connection that in our studies on nude men and women in the Russell Sage calorimeter, the average skin temperatures of the two sexes was quite different under the same circumstances, the women having lower skin temperatures in the cold and higher skin temperatures in the warm environments. Therefore, some care will be necessary in evaluating skin temperature values.

Comfort is essentially a sensation problem and thermal comfort probably represents an environmental exchange in which the number of afferent impulses arising in the skin is minimal. As these impulses are due to changes in skin temperature about a mean value, the mean value of skin temperature, although closely related to comfort, is probably not the basic factor. For example, in uncomfortably warm environments, it is probably the rise and fall in skin temperature due to periodic evaporation and production of sweat which gives rise to the thermal sensations, and the same sensations are probably important in the regulation of body temperature in such environments.

Also in the zone of body cooling, periodic shivering is due partly to the sensation of cold arising from a falling skin temperature. The extreme sensitiveness of the skin to changes in temperature is recalled in this regard: threshold for warmth, a rise of 0.0008 centigrade degree per second for three seconds; threshold for cold, a fall of 0.004 centigrade degree per second for two seconds. I suggest that the average value of the wetted area of the skin may serve as a useful index in the zone of evaporative cooling when the average skin temperature changes but little.

I concur heartily with Professor Yaglou's suggestion that radiation should be included under some circumstances as an important factor. The question of variable forced air currents and their effects on the skin temperature and evaporation losses is another important environmental factor.

W. J. MCCONNELL, M.D.[2] New York. N. Y. (WRITTEN): Professor Yaglou has proposed a rational method, verified by significant experimental evidence, for improving the usefulness of the Effective Temperature Index in comfort cooling and heating which merits favorable consideration. It is expected that the study outlined will furnish data for correcting the effective temperature lines for humidity effects within the range of ordinary temperatures, and thereby greatly enhance the value of the Effective Temperature Index.

THOMAS CHESTER, Detroit, Mich. (WRITTEN): This valuable paper convincingly indicates the need for improving the Effective Temperature Index, and what is more important, how to do it. Research should be started forthwith, in order to eradicate long recognized defects.

In explaining why humidity effects were originally overestimated the statement is made that "in passing from a relatively dry atmosphere to a moist and cooler one, *in the absence of sweat gland activity*, the exposed skin and clothing adsorbed moisture and the heat of adsorption imparted a transient sense of warmth. This supposition of the entire absence of perspiration with skin temperatures under the clothing of around 90 F does not seem to be warranted. When the skin perspires it does so with a controlled and graduated action, instead of a quick on and off effect. The formation of small drops is first noticeable on the forehead and palms of the hands due to the more numerous sweat glands per unit of area at these places. When such incipient exudation is visible, it is conceivable that evaporation is occurring from the pores of the skin beneath the clothing. On this basis it would be simpler and perhaps more accurate to attribute variations in sensations of warmth to variations in evaporation, instead of to adsorption or desorption. Evaporation is governed chiefly by differences in vapor pressure. If there is any evaporation of perspiration, a subject in passing from a relatively dry atmosphere to a moist and cooler one, will for a short time lose less latent heat because of arrested or diminished evaporation, if the vapor pressure of the water vapor in the air in the new environment is higher than in the former one. This reduction in the rate of heat loss from the skin is felt as an increase in warmth. The author goes on to state that *upon returning to the drier room, excess moisture quickly evaporated producing a transient cooling effect.* This of course is correct and is due to the pronounced tendency of moist substances to fall to the prevailing wet bulb temperature. As regards the adsorption theory it is very questionable whether any instrument would show any increase in the temperature of clothing removed and apart from a human body due to moisture regain and the concomitant release of heat caused by the condensation of water vapor within sub-microscopic pores of the fabrics. Regardless of conjectures of how skin warming and cooling sensations are produced, they very definitely are produced when variations occur in the rate of evaporation of perspiration, and divergencies between effective temperatures and average skin temperatures are to be expected.

In carrying out research work on this subject, the usual complexities are to be expected. Perhaps it would be difficult and expensive to have the subjects similarly clothed. If this could be done it would at least eliminate one variable of considerable influence.

The author undoubtedly knows whether or not there is much variation in normal skin temperatures of different individuals when similarly attired, if subjected to the same atmospheric conditions, and a statement from him on this matter would be appreciated. If there is much variation it could of course be suitably dealt with in the production of informative data.

[2]Assistant Medical Director & Director, Industrial Health Section, Metropolitan Life Insurance Co., New York, N. Y.

Comfort Criteria Paramount

DOUGLAS H. K. LEE[3], Brisbane, Australia, (WRITTEN): I will discuss Professor Yaglou's paper under three headings: (1) Inadequacies in present ET (effective temperature) scheme; (2) Expected nature of modifications; and (3) Suggestions.

Inadequacies in Present ET Scheme

Inadequacies in present ET scheme are indicated by:

a. Overestimation of the heating effect of increased humidity at intermediate temperatures.

b. Non-recognition of the *cooling* effect of high humidities at low temperatures, especially with clothing.

c. Non-inclusion of radiation factor.

Note: Data obtained in my laboratory on the relative effect of humidity at high temperatures are now under examination. I should not like to commit myself on the matter at the moment.

Expected Nature of Modifications

a. Thermodynamically, when the body is not actively sweating and the only moisture available for evaporation is that of percutaneous transudation, the rate of which has been shown to be relatively constant, the only effect brought about by an increase in absolute humidity should be that arising from diminished evaporation from the respiratory tract. The extent of this transfer of heat loss from pulmonary evaporation to cutaneous radiation-conduction-convection can be determined from psychrometric tables. The amount would be small and the effect on comfort should be equally small. The environmental temperature fall which would be necessary to balance this could probably be estimated from the John B. Pierce Laboratory data. I should, off hand, expect even less deviation from the dry bulb temperature lines than Professor Yaglou gives in his Fig. 3.

b. Damp air and damp clothing (after equilibration with the atmosphere) offer less thermal resistance and increase heat loss appreciably at moderately low temperatures (35-45 F). It might be expected that the comfort lines, especially for the clothed man, would cross somewhere about 45 F with this reversal of humidity effect.

c. Bedford's recommendation to use globe thermometer temperatures (uncorrected) in place of dry bulb temperatures appears to be justified empirically where radiation is not sharply localized. Alternatively, a scale could probably be worked out for determining radiation corrections to the dry bulb scale where mean radiation temperature of the surroundings is known from thermocouple or radiometer measurements.

Where radiation is intense and from a limited source, (*e. g.* sun fire), the geometry of the globe is so different from that of man that a simple globe thermometer reading might be expected to be inadequate. Moreover, the relative importance attached by man to localized radiation in the assessment of his general comfort is not known.

A further practical difficulty in the assessment of radiation effect is introduced by the time factor. Exposed skin quickly warms up giving immediate sharp sensation with some subsequent fading, but the heat contribution is immediately added to the total load which probably also has some say in sensations of comfort. Clothed skin, on the other hand, warms up quite slowly. Just what shape curve of sensation will result from a given situation is hard to predict, depending upon time, relative areas, nature of clothing, intensity and quality of radiation.

Suggestions

I would make a strong plea for maintaining the original criterion used in the ET scheme; that is, keep it as a comfort index. By all means use other criteria—skin temperatures, thermodynamic predictions—as *checks*, and thoroughly investigate discrepancies to see if the cause lies in the experimental method of assessing comfort (Yaglou suggests one such case) or is inherent in the checking criterion (pulse rates are notoriously bad criteria). But make the final criterion one of comfort. This is not only logical but practicable, since comfort is the item with which the average worker is concerned.

I firmly believe that the final scientific assessment of thermal stress, and thus of potential thermal strain, will be a thermodynamic one; but the day of its realization is still far off. The ET scheme has been the best empirical and practical index to date, and it can be improved. By all means let us have it improved, but retain its basic character.

I would support Professor Yaglou's suggestion that the ASHVE Research Laboratory make a comprehensive review of the ET scheme, and would suggest that its application to fairly low temperatures be also re-examined. If there are to be amendments, and I think there should be, let them all be made at the same time so that the resultant chart can be used for another 20 years without alteration.

[3]Physiology Department, University of Queensland.

Include Radiation Effects

THOMAS BEDFORD, London, England (WRITTEN): It has been my privilege to see an advance copy of Professor Yaglou's valuable paper, and I should like to offer him my congratulations on it. I am glad to learn that the question of revising the effective temperature scale is being discussed. I hope that the project will go forward, and I would urge that in this work radiation be taken into account.

I am much interested in the proposal that effective temperature lines shall be drawn as lines of equal mean skin temperature. There is much to be said for using some objective index instead of comfort votes in constructing a scale of warmth, and I agree that until perspiration comes into play skin temperature is the best available index. At higher temperatures, however, I doubt whether skin temperature alone will be adequate. Then, I think, due allowance should be made for the rate of sweating, and perhaps also for the effects of heat on the heart rate and on body temperature. It may be found necessary to utilize some such overall index of physiological effect as was used by Prof. Sid Robinson and his colleagues[4].

Although for moderate temperatures, skin temperature is the best objective index of comfort, and although it may be of great value in constructing a scale of warmth, it should be borne in mind that when different persons have the same skin temperature they are not necessarily equally comfortable.

The subjective feelings of warmth of a single person can be predicted with considerable accuracy from a knowledge of his skin temperature. Thus, Miss Ward[5] found very high correlations between comfort votes and the skin temperature measured on the forehead or over the carotid artery. Yet, in my own observations on a large number of persons doing very light industrial work[6] in which the skin temperatures of the forehead, hands and feet were measured, it appeared that skin temperature measurements were of little practical value in predicting the comfort of individual persons. The probable range of errors of estimation was such, that, when the combination of forehead, hand and foot temperatures caused the average person to feel exactly comfortable, some persons felt too cool and others too warm. On the whole, the comfort of the individual occupants of a room could be predicted

[4]*American Journal of Physiology*, Vol. 143, p. 21, 1945.

[5]*American Journal of Hygiene*, Vol. 12, p. 130.

[6]Industrial Health Research Board Report, No. 76, 1936.

rather better by estimating the average comfort vote from a knowledge of the equivalent temperature (or of the effective temperature) of the room than by estimating the feeling of warmth of each occupant from a knowledge of his skin temperature.

It may be that by employing the mean skin temperature, as used by Professor Yaglou, a better estimate of comfort will be obtained, but that is a matter which can be tested. The results of my observations serve to reinforce Professor Yaglou's caution that the experimental subjects should be kept unchanged throughout the study.

F. C. McINTOSH, Pittsburgh, Pa. (WRITTEN): The information given in Figs. 2 and 3 might indicate a much greater relative humidity effect between 50 and 80 per cent than between 20 and 50 per cent. As Professor Yaglou indicates by his points, and states in his text, this information comes from a few exploratory tests. Perhaps further information would change this relationship.

Since Professor Yaglou has apparently discovered the reason for the misinterpretation of data taken 25 years ago, I would like to ask him what reason he gives for the effect of relative humidity on skin temperature; also if he thinks the effect would be directly proportional or otherwise as Fig. 3 would indicate; and in the latter case, if the curvature of the skin temperature lines would continue up to 100 per cent?

Questions Conclusions of Incomplete Analysis

W. L. FLEISHER, New York, N. Y. (WRITTEN): In connection with Professor Yaglou's suggestion for a method of improving the Effective Temperature Index, I would take the most profound exception—not only to his conclusions—but to his obvious misconception of the whole subject.

There is really only a very narrow range of effective temperatures which are of particular importance as far as the practical application of air conditioning to human beings in a conditioned environment is concerned. Within this very definitely determined range practically the whole science of comfort conditioning has been built, and the importance of our art and our research is predicated upon the public acceptance of these particular environments. This range has been thoroughly substantiated in the field as correct.

Before I develop this theme farther, I want to criticize Professor Yaglou's assumption that the work he did in the early days of the Laboratory is by any means the basis, or has any important bearing, upon the results which are generally used by the public. When he says that two young men were exposed for a certain number of hours, or when he speaks of Dr. Dubois' experiments, he fails to take into consideration the summer experiments in Minneapolis, Toronto, San Antonio, Washington and New York—where thousands of people, for months, were subjected to very definite conditions of temperature and humidity and expressed a great preference for a narrow range of so-called effective temperatures.

Within this narrow range, I contend that the resultant combination of temperature and humidity—the humidity varying from 30 to 70 per cent—combined with the temperature which created a condition along an effective temperature line corresponding to this temperature and relative humidity, was comfortable to the vast majority of the people, and the deviation from this condition to discomfort on both sides, that is, to a cooler or a warmer condition, is so definitely indicated that there can be little possibility of improper classification.

The phase of air conditioning on which the Society has grown is a summer air conditioning function, created by the use of some type of artificial refrigeration. As I have stated, within the narrow range which I have indicated, developed by these thousands and thousands of tests, the effective temperature is well established, and is not in any way related to the requirements of skin temperature measurements. Why the question of clothing should necessarily enter into this particular analysis, is beyond comprehension. Certainly, the 18 lb of clothing required for the Eskimos has very little to do with this subject at hand, which is more than likely to create a feeling of uncertainty in the minds of the thousands, or even hundreds-of-thousands of people who have benefited from the standards which were originated in the Laboratory, and conclusively proved in the field, to be correct from a practical angle.

Up to this point, I have discussed this paper purely from the angle of summer comfort, as indicated from the composite chart, Fig. 11, p. 219, in THE GUIDE, 1947. I cannot pass over this figure without again calling attention to the discovery of the Fleishers'[7] that the effective temperature line, or so-called effective temperature line, which is in our opinion, the line of constant volume, passes through the 0 per cent relative humidity line on the maximum comfort effective temperature line at the normal body temperature of practically all human beings.

In this discussion of Professor Yaglou's paper, I am not going to enter into the further discussion of the kinetic energy theory developed by the Fleishers, but it has certainly, in my opinion, been much more significant than the points developed by Professor Yaglou.

It was stated earlier in this discussion, that there was another point in the socalled effective temperature setup which was of importance; and that is, outside the comfort range—in the *danger* range. If there is criticism of some of the methods pursued in the past by the Laboratory and consequently the 87 deg ET line is subject to criticism as the critical point for men at light labor, we have the work of Haldane and his associates to corroborate or confirm the work that we have done indicating that this point, or at least some point along the 87 deg ET line is the point where some fairly serious physiological changes take place in human beings. It is my opinion that this condition is not necessarily serious, and Dr. Thomas Bedford, England, who investigated these higher temperature and humidity conditions, in order to cover the safety of employment in the mines of South Africa, has also corroborated the findings of our own Laboratory. Of course, I am sure that Professor Yaglou will contend that these conditions were arrived at physiologically; whereas, the effective temperature lines were determined psychologically or by sensible sensations. However, the equation of relationship between humidities either absolute or relative and dry bulb temperatures remain approximately the same for the *comfort* and *danger* zones. Of course, I must contend again that they follow, particularly in the higher ranges, much more nearly the Fleisher kinetic energy lines, than they do the arbitrary lines developed by the Laboratory. Nevertheless, the relationship between temperature and humidity in the higher ranges is very similar to the equation of relationship in the comfort zones.

Actually the thing that interested me most in Professor Yaglou's paper is his casual disregard of the effect of humidity under cooler conditions. That is, the lack of any effective changes in sensations due to more or less humidity in the winter time under cool conditions. I was not able to understand, in reading his paper, whether he was discussing this whole subject from the angle of the environmental conditions outdoors or indoors. Of course, in Table 1, he mentions *summer clothes, winter indoor clothes, winter outdoor clothes* and *Arctic pile clothing*. Though why he changes from *clothes* to *clothing* is more than

[7] Comfort and Health and Temperature —A Mathematical Solution, by W. L. Fleisher and W. L. Fleisher, Jr. (ASHVE TRANSACTIONS, Vol. 47, 1941.)

I can understand; so that I think he has in a way confused the subject, or the subject about which we are creating discussion. In other words, he attempts to belittle work that has been very advantageous to the development of this art, and because of his name in this art, it is liable to carry weight. This in my mind is not based on anything nearly as thorough or conclusive as the work done by the Laboratory over the past 25 years.

Coming back to the discussion of the field of relative humidity, or we might say, moisture content of the air in the winter time—as he starts with 24 per cent relative humidity and goes up from that point, I think that he has completely weakened his position by not recognizing that in the winter time we are discussing conditions inside an enclosure, such as a residence of not a 30, 40, 50 or 60 per cent relative humidity but conditions of relative humidity that may go well below 20 per cent. I have discussed this question fully, many times; not only before the Society, but before various medical and health groups. On the basis that Professor Yaglou's, Dr. DuBois' and Dr. Winslow's measurements of desirable humidity in the house are all based on physiological measurements to reactions, and their contention that humidity in the winter time is relatively unimportant, is fallacious in the light of people's reactions to dry enclosures, it seems to me a mistake that the crude methods of measurements, which these experts in the line of physiology employ, should be weighed against the sensation of human beings. In most cases in winter, it is not possible to maintain more than 30 per cent relative humidity due to the deposit of moisture on cold surfaces. With conditions of relative humidity between 25 and 35 per cent in the opinion of hundreds of people that I have questioned, and thousands of people that I have exposed to these conditions during the past few years, I am extremely critical of the continued reiteration of Professor Yaglou as to the unimportance of humidity in the winter time.

After all, to be slightly cynical, one must not forget that Professor Yaglou was just as dogmatic about ionization and its importance as he is skeptical of the importance of humidity in the winter time, and that his findings, backed by exhaustive tests undertaken by the Harvard School of Public Health, were completely fallacious.

In conclusion, I would like to bring out these points. The Research Laboratory of the Society, in cooperation with outside sources, has over a period of years, developed completely correct zones of comfort and of physical environmental hazards. We have advocated, due to the Laboratory's various investigations, a minimum relative humidity for comfort in the winter time. There is a possibility that some of the Laboratory's methods were crude and inaccurate; nevertheless, empirically, they have proved practical and acceptable and the growth of the Society is due to a great extent to the usefulness and acceptance of these standards. The casual and incomplete analysis such as Professor Yaglou has given should not in any way affect the acceptance of the prior research of the Society.

Planned Program Essential

A. C. WILLARD, Urbana, Ill. (WRITTEN): This paper deals with an important factor, among many, affecting human comfort in occupied spaces. It raises again the question of the true significance of relative humidity as a component of the Effective Temperature Index. The objective evidence presented is sufficiently convincing to justify the serious consideration of the Society's Committee on Research.

Professor Yaglou's recommendation as shown under Conclusions, item 4, needs clarification as to the nature and extent of program, time, staff and funds necessary to make a comprehensive study of the problem, before final action is taken on assigning the project to the Research Laboratory to execute.

W. E. ZIEBER, York, Pa. (WRITTEN): I think the paper by Professor Yaglou is very timely and important. Several things enter into this subject which, as he points out, need further consideration, and I am satisfied this Society is the proper place to give this the thought that is required at this time.

Professor Yaglou is in a very good position to criticize and comment on the work that has been done and to determine the various portions of work on the subject, that have been able to stand under the test of time, and those parts which have not been able to stand. Because of his past work, I think he is a better critic than most of us.

The attitude that some of the work may have been in error because of the inability to understand certain phenomena, is a very good approach. I believe we should seriously consider some rechecking as suggested by Professor Yaglou. The conditions pointed out are certainly logical and I agree that the Society has a problem which it should study. Professor Yaglou points out that the effects of adsorption of moisture by clothing and the desorption of moisture have a heating and cooling effect. Also the initial skin and moisture conditions, and the change under those conditions are very important. I agree with Professor Yaglou that these conditions must be carefully studied to be able to detect the proper reactions when making observations. I regret that I cannot contribute much toward the method of handling these particular phases. I believe the men who have been working on these subjects can better advise how to take care of such conditions and what type of measurements need to be taken.

Instantaneous readings may be one of the causes of difficulties and further information regarding them may result from an investigation now being made by the ASHVE Committee on Research on the shock effect upon people when entering cooled spaces, or going from cooled spaces to warm spaces.

This phase is involved in physiological and psychological reactions of humans, but I do not see how the Society can divorce this work from the medical or public health professions. They may guide it and act as a clearing house, but the work will have to be carried on by people who are able to understand the reactions of people from these two angles.

The studies of effective temperature should provide answers to more questions than have been considered in the past; that is, we should know the relationship of shock effect and Effective Temperature Index. The work should cover more than a couple of people and it should cover people of different ages. We should know the difference between active and inactive people. The effects of velocity of air, both in cooling and heating, should be studied.

The effect of radiant heating and radiant cooling from objects, panels, and people in groups, should be included in the studies because of the importance that has been put upon this particular subject in the past year or so.

Because of the magnitude of the work required to get this subject straightened out, as it appears now, I believe it is a good thing to make a correction as proposed by Professor Yaglou to improve the methods of selection of effective temperatures for use in laying out and designing air conditioning systems. I believe his work illustrating the relationship between skin temperature and effective temperature can be used by designers to good advantage, especially if humidity does not have much effect on sensation of warmth and comfort at ordinary temperatures. Most air conditioning is applied under ordinary temperatures and does not approach the limits of human endurance to heat. Basically, this is the important thing to correct, if only in a temporary way at this time, considering that the problems involved are numerous and will require considerable work in the future.

If Professor Yaglou's suggestions are adopted, our comfort charts will

need adjusting since the comfort zones are constructed upon the effective temperature lines.

I believe that any future work on effective temperature should be combined with comfort work. The two are not directly related, that is effective temperature lines extend beyond the comfort zones. It is possible, however, to use the same experimental technique and apparatus setup for both studies. Since the comfort zones are based upon effective temperature lines, at present, they will need to be checked at the time the effective temperatures are worked upon to be sure of their boundaries and values.

Comfort and Humidity Related

KENNETH E. ROBINSON, Lansing, Mich. (WRITTEN): The writer is very much interested in this paper, first because as the author states, it has been evident for some time that humidity did not vary the sensation of warmth as greatly as the effective temperature chart would indicate and second because of a nontechnical study the writer carried on for a period of three or four years.

This study consisted in part of checking with customers who had humidifying equipment controlled by a humidistat. Although most of these people, including physicians, had insisted on having equipment capable of keeping a relative humidity of 50-60 per cent when purchasing the equipment, in every case it was found within a year's time that the humidity was maintained at a range of 35-40 per cent and never over 40 per cent.

The other part of the study was confined to a large number of customers who had humidifiers in series with a forced warm air heating system. Ordinarily it was found that this humidifier would maintain a relative humidity in the house of from 25-35 per cent. However, it soon became apparent that if the humidifier was out of service, we would get a call from the customer and the complaint was always the same. The temperature at the thermostat could be maintained, but the home was no longer as comfortable as it had been in the past. It was also found by experimentation that raising the temperature of the building one or two degrees did not compensate for the lack of humidity as concerns human comfort.

We realize that there is a vast difference between the two statements, *sensation of comfort* and *sensation of warmth* and it is my wish to raise the question as to whether both can be placed on one chart. I have asked many physicians what the proper humidity in a building should be in order to maintain the health and comfort of the occupants but to date, I have not received two answers which agree.

The writer wishes to compliment Professor Yaglou on this fine paper and sincerely trusts that the Society will see fit to carry on with the work he has outlined.

Check ET Lines–Data for Improvement Inadequate

CHARLES S. LEOPOLD, Philadelphia, Pa. (WRITTEN): There can be little doubt as to the desirability of an objective test for comfort, if a dependable method can be obtained.

In the general range of optimum comfort, two statements can safely be made:

1. Practically all investigators concede that increase in relative humidity at constant dry bulb produces some increase in the feeling of warmth.
2. For the usual working range the effect of relative humidity is small.

In this paper, Professor Yaglou substantiates the general effect of relative humidity but believes that the effect is approximately one-half as great as that previously reported. It is realized that for the complex and adaptable structure of the human body, this is an extremely small effect to measure.

In effect, Professor Yaglou states that the present effective temperature lines are faulty in the range of ordinary indoor comfort for normally clothed people in sedentary occupation and suggests that for temperatures 82 deg and below we determine the slope of the effective temperature lines by establishing lines of constant skin temperature. For temperatures above 90 deg, he states that relative humidity is probably more important than previously noted and leaves a void in observation for conditions between 82 deg and 90 deg.

Consider, first, his case against the present effective temperature lines.

Reference is made to the paper by Rowley, Jordan and Snyder[8], but in light of the discussion following this paper it would appear that there is serious doubt as to the validity of the conclusions.

Professor Yaglou criticizes the original laboratory work in determining effective temperature lines and states, without offering experimental proof, that the error is due to adsorption and desorption effects. I do not believe that the case for adsorption and desorption phenomena is so simple as it appears. Ferry Houghten pointed out in a discussion of a paper[9] that the dissipation of heat from a human was not equivalent to drying a dish cloth, in which case heat for evaporation must come from without, but that it was more akin to a heated cylinder with a moist fabric jacket, in which case a large part of the heat for evaporation came from within.

In Fig. A of the reference mentioned, it is shown that the rate of drying of a moistened jacket on a metallic cylinder maintained at 98 F was substantially the same at 75.2 F 80 per cent RH as it was at 82 F and 30 per cent RH. Both conditions fall on the 73 deg ET line.

I cannot accept the statement that the effective temperature line stands

[8]Comfort Reactions of 275 Workers During Occupancy of Air Conditioned Offices, by Rowley, Jordan and Snyder. (ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*, June 1947, p. 113.)

[9]Cooling Requirements for Summer Comfort Air Conditioning, by F. C. Houghten, F. E. Giesecke, Cyril Tasker and Carl Gutberlet. (ASHVE TRANSACTIONS, Vol. 43, 1937, p. 145.)

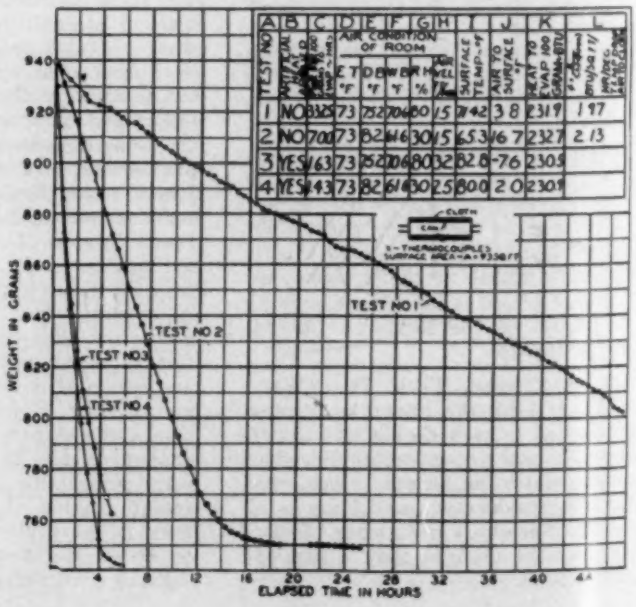

Fig. A—Result of four tests

solely on *instantaneous* effects. In another report[10] of a series of experiments it is stated:

The same subjects took part in each of the eight 2-hour tests, four at 30 per cent and four at 60 per cent RH. To eliminate any effect of acclimatization to a temperature, when changing the conditions the upper and lower limits of the zone were determined by approaching them from opposite directions. Two general methods were followed in conducting the tests. First, the test was started with an atmospheric condition outside the comfort zone for most people, either below or above, and the probable center of the zone was approached by steps of 1 or 2 deg ET. Second, the test was started with a condition within the zone for most subjects and then changed so as to move outward, either to a higher or lower temperature.

The range and direction of the change in temperature for the various tests are shown diagrammatically on the small psychrometric chart in Fig. 2.

This and subsequent papers by other investigators explored the possibilities of longer exposure and if, as Professor Yaglou says, the tolerance increases with time, then it is obvious that this is a factor which must be considered. It does not, however, per se prove that the original sensation is not an accurate index.

In all, though the possibility of errors due to sorption is not questioned, it would appear that adequate proof has not been advanced.

Based on References 5, 6, and 7, the author states that for winter or summer men and women are comfortable if their weighted skin temperature averaged between 91.0 and 93.0 deg, regardless of the type of clothing or the environmental conditions. In all of these papers the ultimate judgment of comfort is subjective. Reference 5 does not record humidity. Reference 6 maintained between 40 and 50 per cent RH for all tests.

All of these papers present extremely valuable information but the real question is: Have we sufficient information available to justify substituting the indirect but objective measurement of skin temperature for a direct subjective test?

The smooth line for 50 per cent RH in Fig. 2 indicates that a 1 deg change in ambient dry bulb would produce a 0.3 deg change in weighted average of skin temperature. Marked deviation from the smooth curve is noted for the points for 75 and 80 F, dry bulb and as between these two readings change in skin temperature is 0.064 deg for each degree change in air temperature. For direct subjective observations, deviation of this magnitude might be expected but these deviations cast considerable doubt on the validity of the objective method, which is intended to be an improvement on the subjective test. The paper does not state whether the points in Fig. 2 represent the average of the two individuals used in the tests. If they represent an average, then the deviation assumes even greater importance.

In the summary, the author makes three definite statements and one recommendation. The three statements do not appear to be substantiated by the presentation as the proof is inadequate for either the failure of the present data or for the desirability of substituting the indirect objective skin temperature for the previous direct subjective method. As to the recommendation, there can be little question as to the advisability of further experimentation to correct or affirm the effective temperature lines, particularly the determination of the winter optimum. Investigation of weighted skin temperature may be in order provided the significance of the data is not assumed in advance of the experiments.

I suggest for consideration the possibility of a continuation of the type experiment originally described by Ferry Houghten in the paper[11] previously mentioned, in the hope that it would provide a better theoretical background for the effective temperature concept.

ROBERT ARNOLD, Philadelphia, Pa. (WRITTEN): This paper presented by Professor Yaglou is, of course, well in line with his usual very careful study of this important subject. The paper is quite apropos inasmuch as many things came about since 1923 which should make it quite natural that the Effective Temperature Index be investigated again.

It is quite important that Professor Yaglou has brought out the fact that exposed skin and clothing adsorb moisture and this, of course, imparts a sense of warmth in passing from a relatively dry atmosphere to a moist and cooler one.

I am especially interested to note that Professor Yaglou has brought out the fact that no other index can compete with ET in a certain definite region except when radiation effects are important. It seems to me that radiation effects have been very much overlooked in the past.

Undoubtedly the idea of mean skin temperature application represents a very rational method for correcting the present ET index and should be given further study.

R. W. KEETON, M.D., Chicago, Ill. (WRITTEN): After thinking over Professor Yaglou's paper I cannot see any serious objections to his conclusions.

In the first place I think that he is correct on insisting that votes of comfort be taken after the subject is in the steady state. The entrance votes will certainly be influenced by the effect of heat input when moisture is added to the clothes and heat loss when it is abstracted.

I believe that the second important point is the correlation of the skin temperature with comfort. The skin temperature is determined by the quantity of blood flowing through it. If heat is lost in evaporation or by radiation, the glomus shunts close down and reduce the flow. If the process is reversed then they open and more blood flows through the skin. In a steady state the blood flow will conceivably be such as to stimulate say x hot spots and y cold spots. It may shift so slowly that only after the temperature of skin has been reduced, say 3 deg, will the number of cold spots stimulated exceed greatly the number of hot spots. Then the subject votes *cold*. In a similar manner he will come to vote *hot or warm*.

It should of course be appreciated that the more rapidly the changes occur the easier it will be to recognize the alterations in sensations. The production of cold sensation by the application of ether to the back of hand is an illustration. A layer of clothes over the body slows the rate of heat exchange with the environment and makes it more difficult for one to arrive at a satisfactory vote expressing the gradation of comfort.

The correlation of the skin temperature with comfort should be made by a zone or a family of skin temperatures with experimentally determined limits. This would seem to be the answer to the question in the zone of vaso-motor regulation. For this reason radiation effects and protection of clothing are most important modifying agents.

I should like to think that the regulation of the skin temperature is first a local one by way of local reflexes affecting the glomus bodies. This allows a minute effect to spread locally and gradually involve an area sufficiently large to produce a recognition of a sensory change.

AUTHOR'S CLOSURE: I wish to thank the gentlemen who discussed my paper, particularly the physicians and physiologists whose comments on body heat regulation should be of distinct value to the engineers.

Answering questions collectively, there are three ways in which humidity may affect skin temperature: (*a*) by its influence on evaporation from the skin which becomes significant at high temperatures when the skin sweats, (*b*) by altering the thermal conductivity of clothing and, (*c*) through some local action on the respiratory mucosa capable of producing reflex changes of blood supply to the skin particularly to the extremities. The relative importance of these fac-

[10] Determination of the Comfort Zone. by F. C. Houghten and C. P. Yaglou. (ASHVE TRANSACTIONS, Vol. 29, 1923, p. 361.)

[11] Loc. cit. Note 9.

tors varies greatly and the sum total effect is not in all probability a straight line function of humidity.

An important point which is not generally appreciated by engineers is that there are two forms of perspiration, *insensible* and *sensible*. The former is transudation of water through the blood capillaries and skin and involves no sweat gland activity. Such insensible perspiration takes place at all temperatures below the comfort point when there is no need for sweating. The amount of exudation is small and practically constant regardless of humidity, and, except in very low temperatures, regardless of temperature also. Obviously no more moisture can evaporate than is exuded, and variations of humidity should, therefore, have little or no effect, so long as the sweat glands remain inactive, as the late Mr. Houghten himself, among many others, had shown. Variations of humidity do affect evaporation from the lungs substantially in proportion to the vapor pressure difference, but the effect is small since the amount of air breathed is only ¼ cfm in men at rest.

Sensible perspiration is the product of sweat glands which begin to secrete in warm atmospheres when heat loss by radiation and convection is significantly reduced. The cooling of the human body by evaporation of sensible perspiration differs from that of an inanimate wet surface in that the body itself controls the rate of sweating in accordance with requirements for heat balance. More sweat glands are thrown into action when the humidity is high than when it is low in order to increase the wet surface and thus maintain needed evaporation in the face of decreasing vapor pressure differential. The limit of evaporative regulation is reached when the rate of sweating exceeds the evaporative capacity of the atmosphere. No one denies the vital importance of humidity in such hot atmospheres.

My paper deals primarily with possible humidity effects on insensible perspiration in the range of comfort heating and cooling where the sweat glands are inactive and where body heat regulation is achieved largely by changes of skin temperature. We need not worry about hot atmospheres at this time until we have first explored the ordinary air conditions in which we live and work. Although from the standpoint of body heat loss we are interested in the mean skin temperature of the whole body, from the standpoint of warmth or cold we are essentially concerned with changes of mean skin temperatures in response to environmental changes. Attempts to correlate changes of forehead, cheek, hand or foot temperatures with sensations of warmth or comfort proved unsuccessful because different areas of the body responded differently to environmental changes.

Although the subjective feeling of warmth of an individual correlates well with his mean skin temperature, different individuals may differ as much as 3 F deg in skin temperature under identical conditions. This does not imply insensitivity of the skin. As Dr. Hardy has pointed out, a rise of but 0.0015 F deg of skin temperature in three seconds is sufficient to evoke a sensation of warmth, and a drop of 0.007 F deg in two seconds, a sensation of cold. Individual variations of skin temperature at least in part, seem to be related to differences in metabolic rates. As a rule, persons with low metabolic rates per unit of body surface area show lower mean skin temperatures than persons with high rates, as is to be expected, since their heat loss is also lower.

Reliance must, therefore, be placed on changes of mean skin temperature, in response to environmental changes, in determining air conditions that are alike in warmth. The subjects must be carefully chosen; they must be dressed alike according to the season, and all skin temperature measurements must be made by one and the same method throughout.

The cost of the proposed study to the Society's Research Laboratory, covering conditions within the winter and summer comfort zones and including radiation effects, should not exceed $12,000. With two observers, five men and five women subjects, it will probably take about six months to complete the study, allowing two to three months for the winter tests and an equal period for the summer tests.

CLARK TO REPRESENT AMERICAN AIR FILTER

L. O. Ray Clark, former district manager of the B. F. Sturtevant Co. at Hartford, Conn., has accepted an appointment as sales representative with the American Air Filter Co., Louisville, Ky.

Born in Medway, Mass., Mr. Clark received his mechanical engineering degree from Worcester Polytechnic Institute in 1902. For nearly 40 years he has been connected with the B. F. Sturtevant Co. and has served in various capacities with manufacturing companies in Cleveland, Chicago and Hartford.

A member of the ASHVE since 1944, Mr. Clark also holds membership in the Hartford City Club, the Avon Country Club, and the Hartford Alumni of Worcester Polytechnic Institute.

CHICAGO CONTRACTORS ELECT OFFICERS

At the recent meeting of the *Heating, Piping & Air Conditioning Contractors' Chicago Association*, C. H. Schicht was elected president and R. W. Lawinger was named vice president. Several of the officers elected are also members of the Illinois chapter of the ASHVE and among them are C. W. Johnson, treasurer; J. S. Kearney and C. E. Crone, members of the board of directors; R. M. Getschow, S. A. Pope, H. M. Hart, and A. H. Goelz as alternates for the new arbitration committee. L. T. Braun, also an Illinois Chapter member, continues in the office of executive secretary.

A. G. SUTCLIFFE RETIRES

After serving a total of 37 years with the Ilg Electric Ventilating Co., Chicago, Ill., A. G. Sutcliffe retired on July 1, 1947. Raymond V. Pfautsch has been appointed chief engineer to succeed Mr. Sutcliffe, who filled the position for the past 20 years.

A member of the ASHVE since 1918, Mr. Sutcliffe has been active in the technical activities of the Society and served as president of the Illinois Chapter in 1931.

WALKER JOINS CONSOLIDATED

Kirby Walker, formerly chief engineer, American Gas Machine Co., has recently been appointed chief engineer, Consolidated Industries, Inc., Lafayette, Ind.

A native of Boston, Mass., Mr. Walker was born on April 13, 1902. After several years of experience in design, supervision, installation, and service of heating systems, he joined the American Radiator Co. in 1933 as a development engineer. Associated with the Glenn L. Martin Co. and Fairchild Aircraft during the war, his work dealt with aircraft cabin and wing heating. Some important developments in heat transfer and the design of heat exchangers were also effected under Mr. Walker's supervision.

Mr. Walker has been a member of the Society for many years and is a licensed professional engineer.

B. M. Woods
President
ASHVE

W. E. Heibel
General Chairman
Committee on Arrangements

ANNUAL MEETING IN FEBRUARY

The Society's 54th Annual Meeting will be held in New York, February 2-5, 1948. The New York Chapter will act as host and the Committee on Arrangements, headed by Walter E. Heibel, general chairman, held its organization meeting on August 18. Meeting headquarters for Society sessions will be at the Hotel Commodore.

Members have received, through the mail, special application forms for hotel reservations and it is recommended that these forms be used in order that the desired accommodations may be assured.

The Meetings Committee of the Council is planning the technical program and announcement of the subjects for discussion will be made soon.

The personnel of the Committee on Arrangements is: *General Chairman*, Walter E. Heibel. *Honorary Chairmen*, Homer Addams, W. H. Driscoll, W. L. Fleisher, D. D. Kimball and Alfred J. Offner. *Vice Chairmen*, Peter B. Gordon, H. S. Johnson, Carl F. Kayan, C. S. Koehler and H. J. Ryan. *Committee Chairmen: Banquet*—W. A. Swain; *Entertainment*—H. J. Rose; *Exposition*—C. F. Roth; *Finance*—W. M. Heebner; *Ladies*—H. S. Wheller; *Publicity*—Clifford Strock; *Reception*—M. C. Giannini; *Sessions*—H. S. Birkett; *Secretary*, Carl H. Flink.

Coincident with the Society's Meeting, the 8th International Heating and Ventilating Exposition will be held in Grand Central Palace, opening at 2:00 p. m., February 2, and continuing until February 6.

G. L. Tuve
Second Vice President
ASHVE

M. C. Giannini
President
New York Chapter

8TH EXPOSITION

Following the tremendous interest in the 7th International Heating and Ventilating Exposition held earlier this year in Cleveland, the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS will again sponsor the nation's leading air conditioning show. The 8th International Heating and Ventilating Exposition will be held in New York, February 2-6, 1948, in the Grand Central Palace during the Society's 54th Annual Meeting.

Early in the year, when the Council of the ASHVE concluded its careful examination of all factors relative to the Exposition, it reaffirmed its approval of the plan of holding the Exposition annually until 1950 under Society auspices. Favorable reaction to the announcement of the 1948 Exposition has been shown by the almost immediate reservation of a large percentage of the available exhibit space in the Grand Central Palace. Action by exhibitors brought reservations for about 400 spaces, completely filling the first floor, the mezzanine (the second floor), the third floor, and all but a limited portion of the fourth floor.

It is the belief of the ASHVE that progress in research and developments in the industry should be made known to its members and to others in related fields through every possible means in order that the greatest possible benefits may be derived by all concerned. Through visual exhibits, technical papers and general discussions the Society has always endeavored to transmit and exchange information relating to the science of heating, ventilating and air conditioning. It is with the idea of broadening these avenues of information that the annual Exposition and concurrent sessions of the ASHVE will be held.

The Society extends a sincere invitation to other societies and their members to attend ASHVE sessions and the 8th International Heating and Ventilating Exposition in New York in 1948. Advances in the science have been greater with each passing year and it is believed that current and future research will further add to the public knowledge. Thus, every possible step is being taken to disseminate available information.

JOURNAL SECTION

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When the replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 34 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by September 25, 1947, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

BAREITHER, HARLAN D., Grad. Student, University of Illinois. PROPOSERS: S. Konzo, J. R. Fellows. SECONDERS: R. S. Buckley, R. W. Roose.

BROWN, COY W., Engr., General Electric Co. PROPOSERS: F. H. Faust, W. E. Johnson. SECONDERS: D. W. McLenegan, R. U. Berry.

CLEGG, EUGENE, Steamfitter, H. G. McGill & Sons. PROPOSERS: H. G. McGill*, W. A. Seckinger*. SECONDERS: T. E. McCollough*, R. E. Rucker*.

COSTELLO, PHILIP F., Mgr., Costello Bros. Engineering Co. PROPOSERS: M. Moucha*, John Carapella*. SECONDERS: Ray Shuster*, Grant Sprague*.

COX, ROBERT M., Installation Supvsr., Florida Hill York Corp. PROPOSERS: S. L. Hamilton*, D. S. Sterner. SECONDERS: P. H. Erisman, Jr., M. W. Wise.

CURTIS, GRANT B., JR., Htg. Engr., Crane Co. PROPOSERS: G. R. Bilderback, R. H. Yancey, III. SECONDERS: Jack Croley, L. L. Barnes.

DEE, VAUGHN C., Estimator, Gorman-Lavelle Co. PROPOSERS: R. W. Dickson, Jr., E. F. Morse. SECONDERS: C. E. Noel, Paul Gayman.

DYER, WILLIAM K., Dist. Mgr., Buffalo Forge Co. PROPOSERS: C. C. Cheyney, Carl Clegg. SECONDERS: E. K. Campbell, Kirk Campbell.

EARP, SAMUEL F., Sales Repr., Preferred Utilities Manufacturing Corp. PROPOSERS: G. R. Walz, W. C. Jones. SECONDERS: J. T. Jones, E. H. Taze.

FELDSTEIN, HAROLD, Mgr., Valley Temperature Control Co. *(Advancement)* PROPOSERS: E. F. Dawson, H. V. Frankenfeld. SECONDERS: E. M. Sims, W. B. Loeffler.

FIELD, ERLUND, Vice-Pres., Whitty Co., Inc. PROPOSERS: Adolph Ehrenzeller, L. A. Brissette. SECONDERS: W. J. Ahearn, C. T. Flint.

GALLAGHER, JAMES M., JR., Partner, J. M. Gallagher Co. PROPOSERS: W. C. Armistead, Foskett Brown. SECONDERS: V. M. Lathers, R. H. Ackermann.

GREGORNIK, NICHOLAS A., Engr., R. B. Hayward Co. PROPOSERS: W. A. Kuechenberg, J. E. Patten. SECONDERS: M. J. Bamond, George Bornquist.

HOFFMAN, HARRY B., Owner, Hoffman & Hoffman Co. PROPOSERS: C. Z. Adams, P. L. Guest, Jr. SECONDERS: W. H. Sullivan, Jr., J. E. Hart.

HUNTINGTON, R. LEE, Engr., Ben Huntington & Son. PROPOSERS: I. P. Fulmor, L. B. Davenport. SECONDERS: C. S. Anderson, J. S. Earhart.

JACOBSON, ELLIOT L., Estimator, A. D. Jacobson Plumbing & Heating Co., Inc. PROPOSERS: P. C. Leffel, H. G. Faust, Jr. SECONDERS: A. D. Jacobson, Henry Gould.

KAUPP, CHARLES W., Engrg. Draftsman, Beman & Candee. PROPOSERS: M. C. Beman, B. C. Candee. SECONDERS: Herman Seelbach, Jr., S. M. Quackenbush.

LAMOREUX, PHILIP J., Sales Engr., E. R. Clement, Inc. PROPOSERS: E. R. Clement, R. M. Toucey. SECONDERS: G. F. Nieske, C. L. L'Hommedieu.

MANIVELU, M., Engr., Spencer & Co. PROPOSERS: E. W. Kutil*, C. R. Navinger*. SECONDERS: J. M. Baragar*, H. L. Scott*.

MCCLEAN, F. C., Pres. & Treas., Fred C. McClean Heating Supplies, Inc. PROPOSERS: W. J. Osborn, J. M. High. SECONDERS: E. J. Ritchie, R. W. Cumming.

MERKER, WILLIAM T., Student, Purdue University. PROPOSERS: W. T. Miller, C. F. Warner. SECONDERS: S. Clark*, G. A. Hankins*.

MONTGOMERY, C. T., SR., Partner, Bowman & Montgomery Co. PROPOSERS: J. E. Axeman, W. S. Anderson, Jr. SECONDERS: J. F. Pfeiffer, R. D. McLain.

NAQVI, M. A., Instructor, Refrigeration School of Military Engineering. PROPOSERS: H. H. Nightingale*, J. Crawford*. SECONDERS: M. S. Gupte*, R. D. Hoskin*.

NEWELL, ROBERT W., General Electric Co. PROPOSERS: B. N. Hoberg, F. C. Allen. SECONDERS: E. J. McEahern, H. J. Woehlke.

PECK, J. W., Mech. Engr., Kroeschell Engineering Co. *(Advancement)* PROPOSERS: W. A. Kuechenberg, A. H. Goelz. SECONDERS: S. S. Sommerfield, W. F. Christmann.

RAMONEDA, ENRIQUE, Cons. Engr. *(Advancement)* PROPOSERS: A. J. Offner, H. W. Wolters. SECONDERS: S. H. Downs, W. G. Schlichting.

RAPP, EDGAR A., Dist. Repr., General Electric Co. PROPOSERS: F. H. Faust, R. U. Berry. SECONDERS: D. W. McLenegan, W. E. Johnson.

ROSS, BURTON W., Sales Engr., South African General Electric Co. PROPOSERS: Robert Bowie, Jacob Ehlers. SECONDERS: T. L. Maggini*, Jules Podnossoff*.

SHEDROFF, DAVID I., Civil Engr., U. S. Bureau of Reclamation. PROPOSERS: B. H. Spurlock, Jr., B. N. Hoberg. SECONDERS: F. C. Allen, E. J. McEahern.

SHELLEY, KARL B., Field Engr., Wertz Engineering Co. *(Advancement)* PROPOSERS: J. O. Kirkbride, H. M. Parent. SECONDERS: E. S. Wilkins, E. K. Wagner.

SMITHERS, THEODORE, Student, Purdue University. PROPOSERS: W. T. Miller, C. F. Warner. SECONDERS: S. Clark*, L. E. Beck*.

THOMPSON, IAN J., War Dept. Fuel Technologist, The War Office. PROPOSERS: W. E. Daniel, A. L. Longworth. SECONDERS: J. N. Williams*, A. C. Pallot*.

WHITE, F. R. L., Chief Tech. Officer, Brightside Foundry & Engineering Co., Ltd. PROPOSERS: Walter Harding, R. E. Otter. SECONDERS: L. C. Watts, B. C. Oldham*.

WHITE, RALPH A., Owner, White Engineering Co. PROPOSERS: M. F. DuChateau, Henry Hoffman. SECONDERS: F. R. Holliday, W. D. Graham.

*Non-Member.

Candidates Elected

JOURNAL SECTION

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by **Art. B-III**, *Section* 8, of the By-Laws, the following list of candidates elected:

Members

AVERY, EDWARD G., Sales Engr., Sarco Co., Inc., Chicago, Ill.

BARBECK, WILLIAM R., Partner, Rodgers-Barbeck Co., Dallas, Tex.

BERGER, JOHN V., Refrig. & Air Cond. Engr., McCombs Refrigeration Supply Co., Denver, Colo.

BROWN, E. BURT, JR., Pres., Reynolds Corp., Chicago, Ill.

CROCKFORD, RICHARD H., Mech. Engr., Reliance Engineering Co., Charlotte, N. C.

DANIEL, CHARLES E., Cons. Engr., Baltimore, Md.

DICKSON, ROBERT W., JR., Field Engr., American Blower Corp., Cleveland, Ohio *(Advancement)*

DIRECTOR, ISADORE, Engr., L. S. Tarleton, Philadelphia, Pa. *(Advancement)*

FLARSHEIM, CLARENCE A., Owner, Kansas City, Mo. *(Advancement)*

HIERONYMUS, R. E., Partner, Aldis & Co., Chicago, Ill.

KING, DAVID J., Sales Engr., American Blower Corp., Detroit, Mich.

KOENIG, MAX, Engr., Balsthal, Switzerland.

KREISMAN, HERBERT, Vice-Pres., Advance Heating & Air Conditioning Corp., Chicago, Ill.

KROGMAN, WESTON L., Acting Supt., The University of Chicago, Chicago Ill.

LARKIN, JOHN A., SR., Sales Engr., Energy Control Co., New Haven, Conn.

LEBRUN, PAUL, Chaudieres & Radiateurs, Brussels, Belgium *(Reinstatement)*

LESLIE, DONALD G., Vice-Pres., The Torrington Manufacturing Co., Torrington, Conn.

LOWE, JOHN B., Pres., Texas Distributors, Inc., Dallas, Tex.

LUNDT, ERNEST C., Pres., Ernest C. Lundt, Inc., Little Falls, N. J.

MANSELL, GEORGE R., Director & Estimator, Purdy Mansell, Ltd., Toronto, Ont., Canada.

MOORE, ALEXANDER G., Cons. Engr., Montreal, Que., Canada.

ROBINSON, PARKE D., Research Engr., Stainless & Steel Products Co., St. Paul, Minn.

SCHENCK, WILLIAM P., Chief Engr., Petrol Corp., Philadelphia, Pa.

SQUIER, RALPH T., Asst. Dir. of Research, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

SWAN, RICHARD E., Pres., Hirsch-Swan Corp., Oklahoma City, Okla.

WATCHLER, WILLARD J., Asst. to Chief Engr., Cleveland Steel Products Corp., Cleveland, Ohio.

WHITTAKER, GEOFFREY S., Mech. Engr., Albert Kahn Associated Architects & Engineers, Detroit, Mich.

Associate Members

AHLRICHS, HERMAN, Owner, H. Ahlrichs Plumbing & Heating Co., New Hyde Park, L. I., N. Y.

ANDERSON, ERIK A., Asst. Dist. Engr., B. F. Sturtevant Co., Div. of Westinghouse Electric, Atlanta, Ga.

ANGLIN, THOMAS G., Cons. Engr., T. G. Anglin Engineering Co., Ltd., Montreal, Que., Canada.

BIGHAM, BRUCE H., Htg. Dept., Nelson Co., Detroit, Mich.

BORZELLO, NICK., Engr., Drying Systems, Inc., Chicago, Ill.

BROWN, MORRIS, Engr., Bldg. Service Div., Stone & Webster Engineering Corp., Boston, Mass. *(Reinstatement)*

BRUNN, CLAIR G., Engr., Drying Systems, Inc., Chicago, Ill.

DOUGLASS, THOMAS C., JR., Constr. Supt., Western Asbestos Co., San Francisco, Calif.

DUKELOW, JAMES S., Mech. Coordinator, Long Construction Co., Kansas City, Mo.

DUTCHER, H. S., Air & Refrigeration Corp., New York, N. Y. *(Reinstatement)*

EAMER, MAURICE B., Tech. Asst., London County Council, Westminster, England.

ELMZEN, HARRY R., Engr., Drying Systems, Inc., Chicago, Ill.

ERIKSEN, WILBUR R., Pres., Airgram Corp., Flushing, N. Y.

FAIRCHILD, HAROLD P., Field Engr., Frank A. McBride Co., Paterson, N. J.

GAINES, E. F., Vice-Pres., Joplin Cement Co., Joplin, Mo.

HANKINS, RICHARD P., Cons. Engr., Richmond, Va. *(Reinstatement)*

HOLLIDAY, FRANK R., Operator, F. R. Holliday & Co., Greensboro, N. C.

HOWARD, FRANK B., Partner, Marshall-Neil, Houston, Tex.

JOHNSTON, T. WALTER, Mgr., Auburn Sheet Metal Works, Auburn, Calif.

KEELER, FORREST E., Sales Engr., C. W. Parsons, Inc., Los Angeles, Calif.

KELLEY, WILLIAM P., Engr., Drying Systems, Inc., Chicago, Ill.

KNOBLAUCH, HENRY K., Partner, Knoblauch-Pierson Engineering Co., Minneapolis, Minn.

KOCH, JOSEPH J., Partner, J. F. Shelton Co., Memphis, Tenn.

LEE, WILLIAM R., Bldg. Supt., Beacon Bldg., Tulsa, Okla.

MCKEE, THOMAS M., JR., Partner, J. F. Shelton Co., Memphis, Tenn.

MILLER, KENNETH W., Mech. Engr., Grudem Bros. Co., St. Paul, Minn.

NASH, RICHARD C., Asst. Engr., Empire Gas & Equipment Co., Denver, Colo.

RAY, GEORGE A., Sales Engr., Horne-Wilson, Inc., Orlando, Fla.

REED, VERNON E., JR., Mech. Designer, A. M. Strauss, Fort Wayne, Ind.

SEELINGER, HAROLD N., Designer, Meyer, Strong & Jones, Inc., New York, N. Y.

SHARP, JOHN E., Owner, Sharp's Stoker and Heating Co., Springfield, Ill. *(Reinstatement)*

SHERIDAN, THOMAS J., Burns Bros., New York. N. Y.

SHIMAZAKI, THOMAS T., Mech. Engr., Ellerbe & Co., St. Paul, Minn.

SIMPKINS, ARTHUR C., Mgr., Mech. Dept., Canadian Comstock Co., Ltd., Leaside, Ont., Canada.

SIMPSON, EDWARD H., Design Engr., Cargocaire Engineering Corp., New York, N. Y.

SMITH, OSCAR L., Sales Engr., McDowell Heating & Cooling, Inc., St. Louis, Mo.

STEVENS, TIBOR R., Htg. Engr., Sarcotherm Controls, Inc., New York, N. Y.

SWARTZBERG, JOSEPH, Engr.-Draftsman, Thermaire, Ltd., Port Elizabeth, South Africa.

THRAILKILL, HARRY K., Htg. Dept., American Radiator & Standard Sanitary, Columbus, Ohio.

TORRY, CHARLES, Chief Engr., J. H. Lock & Sons, Ltd., Toronto, Ontario, Canada.

WALTERS, RICHARD R., Sales Engr., Modine Manufacturing Co., Minneapolis, Minn.

WEBSTER, GEORGE C., Engr., John G. Webster, Washington, D. C.

WENDEL, FREDERICK E., Proj. Mgr., The Frank A. McBride Co., Paterson, N. J.

WILLIAMS, GLENN, in charge of Refrig. Field, Hayes Brothers, Inc., Indianapolis, Ind.

YOUNG, ROBERT H., JR., Htg. Engr., A. P. Engelhart Co., Flint, Mich.

Junior Members

ARNOLD, JONAH S., Draftsman, Parsons, Brinckerhoff, Hogan & MacDonald, New York, N. Y.

GLASPIE, DONALD L., JR., Engr., Shelby-Skipwith, Inc., Memphis, Tenn.

GRAHAM, WILLIAM D., JR., Sales Engr., The Trane Co., Greensboro, N. C.

HARGIS, A. H., Engrg. Draftsman, T. F. Hargis, Jr., Yakima, Wash.

KORNBLUM, HERBERT R., Htg. Engr., Davis & Warshow, New York, N. Y.

KUHLMAN, CHARLES E., Detroit, Mich.

KUN, IRVING B., Mech. Engr., L. S. Tarleton, Philadelphia, Pa.

LAYTON, ROBERT E., JR., Sales Engr., L. O. Layton Supply Co., Tyler, Texas *(Advancement)*

MCGAVOCK, EDWARD A., Sales Engr. Forest City Heating Co., Rockford, Ill.

MURPHY, THOMAS E., Asst. Chem. Engr., Lincoln Electric Co., Cleveland, Ohio.

STRONG, ARTHUR P., JR., Draftsman, Drying Systems, Inc., Chicago, Ill.

THOMAS, JAMES E., JR., Engr. & Draftsman, R. L. Deppmann Co., Detroit, Mich.

VANDERFORD, JAMES R., West Lafayette, Ind.

WHITTIER, F. WESTON, Sales Engr., American Oil Burner Corp.

Student Members

BUDDE, WILLIAM R., Student, Purdue University, West Lafayette, Ind.

CARLSEN, HOWARD J., Student, Michigan College of Mining and Technology, Houghton, Mich.

DORFFI, ARTHUR A., Student, Michigan College of Mining and Technology, Houghton, Mich.

FRICKE, ROBERT A., Student, Michigan College of Mining and Technology, Houghton, Mich.

HOFF, OLIVER I., Student, Michigan College of Mining and Technology, Houghton, Mich.

MCKIE, THOMAS G., Student, Michigan College of Mining and Technology, Houghton,, Mich.

MEYER, ROBERT P., Student, Purdue University, West Lafayette, Ind.

YARDLEY, JACK E., Student, Purdue University, West Lafayette Ind.

T. P. MANDELL IN TRAGIC PLANE CRASH

Thomas Proctor Mandell, Boston, Mass., died on August 7, 1947, when the chartered plane on which he was a passenger, en route from Montreal to Boston, plunged into a large oil and gas furnace at Everett, Mass. His two younger daughters, Ann and Harriet, nineteen and twenty-two years of age, were also killed.

A native of Beverly, Mass., Mr. Mandell was born on November 19, 1901. He attended St. Mark's School, Southboro, Mass., preparatory to attending Harvard University and the Massachusetts Institute of Technology.

From 1933 until 1936 he served as a sales engineer for several concerns in Boston. In 1936, Mr. Mandell joined the Carrier Corporation, Syracuse, N. Y., as a representative in the New England area. He organized the Carrier-Mandell, Inc., with Earl Carrier in 1946. A member of the Society since 1937, Mr. Mandell was also affiliated with the Air Conditioning Bureau of Boston.

The Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their deepest sympathy to his widow, Mrs. Geraldine Clark Mandell, and his daughter, Mrs. Cyril Craig, Montreal, for their loss.

R. F. HAHN DIES AT 36

The ASHVE was recently advised of the death of R. F. Hahn, Atlanta, Ga., in October, 1946, at the age of 36.

Mr. Hahn was born in Gary, W. Va., on July 20, 1910. He attended the Jenkins, Ky., high school preparatory to entering the University of Kentucky. Following his graduation in 1934 with a B.S. in mechanical engineering, Mr. Hahn was engaged by the Frigidaire Corp., Dayton, Ohio, for promotional work in air conditioning at the Chicago World Fair. Shortly after, he entered the Atlanta branch of the Frigidaire Corp. as a sales engineer. At the time of his death Mr. Hahn was employed as an engineer by the Advance Refrigeration, Inc., Atlanta, Ga.

A member of the Society since 1936, he was affiliated with the Atlanta Chapter and also held memberships in the *ASME* and *AIEE*.

T. F. CAMPBELL DIES AT 57

Thomas F. Campbell, Pittsburgh, Pa., a member of the ASHVE for nineteen years, died in his home on August 1, 1947.

Born in Pittsburgh on January 12, 1890, Mr. Campbell attended Carnegie Institute of Technology, where he received a B.S. degree in electrical engineering in 1908. From 1908 until 1917 he was engaged in engineering work for the Duquesne Light Co.

During the first World War he served with the U. S. Army 37th Engineers. Following the war he went into the automatic control business, serving as a distributor for the Minneapolis-Honeywell Regulator Co., Wilkinsburg, Pa., and other firms.

Surviving Mr. Campbell are his widow, Mrs. Hulda Sumner Campbell, his two daughters, Betty and Barbara Campbell, and two sisters, Mrs. M. C. Hockswender and Mrs. Helen C. McKee, to whom the Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their sincerest sympathy.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

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Michigan: Organized, 1916. Headquarters, Detroit, Mich. Meets, First Monday after 10th of month. President, A. E. Knibb, 1003 Maryland Ave., Detroit 30. Secretary, L. A. Burch, 5853 Hamilton Ave., Detroit 2.

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Nebraska: Organized, 1940. Headquarters, Omaha, Neb. Meets, Second Tuesday. President, Verne Simmonds, 2416 Vane St., Omaha. Secretary, G. W. Colburn, 106 N. 15th St., Omaha 2.

New York: Organized, 1911. Headquarters, New York, N. Y. Meets, Third Monday. President, M. C. Giannini, New York University, New York 53. Secretary, Carl H. Flink, Room 3000, 51 Madison Ave., New York 10.

North Carolina: Organized, 1939. Headquarters, Durham, N. C. Meets, Quarterly. President, C. Z. Adams, 312 Piedmont Bldg., P. O. Box 1356, Greensboro. Secretary, M. F. DuChateau, 205 S. Lyndon St., Greensboro.

North Texas: Organized, 1938. Headquarters, Dallas, Tex. Meets, Third Monday. President, C. R. Gardner, 1000 St. Louis St., Dallas 1. Secretary, G. A. Linskie, 3124 Milton St., Dallas 5.

Northern Ohio: Organized, 1916. Headquarters, Cleveland, Ohio. Meets, Second Monday. President, John James, 3170 W. 104th St., Cleveland 11. Secretary, W. M. Rowe, 1302 Swetland Bldg., Cleveland 15.

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Oklahoma: Organized, 1935. Headquarters, Oklahoma City, Okla. Meets, Second Monday. President, W. W. Frankfurt, 519 Apco Tower, Oklahoma City. Secretary, J. H. Spaan, Jr., 1300 N. Klein, Oklahoma City 6.

Ontario: Organized, 1922. Headquarters, Toronto Ont., Canada. Meets, First Monday. President D. A. Stott, 195 Spadina Ave., Toronto. Secretary, H. R. Roth, 57 Bloor St., W., Toronto, Ont.

Oregon: Organized, 1939. Headquarters, Portland, Ore. Meets, Thursday after First Tuesday. President, C. W. Brinsenden, Electric Bldg., Portland 5. Secretary, L. G. Williams, Box 304, Gladstone.

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Pacific Northwest: Organized, 1928. Headquarters, Seattle, Wash. Meets, Second Tuesday. President, E. F. Langdon, 72 Vine St., Seattle. Secretary, E. J. Rosen, 10238 18th Ave., S. W., Seattle 66.

Philadelphia: Organized, 1916. Headquarters, Philadelphia, Pa. Meets, Second Thursday. President, E. H. Dafter, 12 S. 12th St., Philadelphia 7. Secretary, L. A. Childs, 330 Harrison Ave., Glenside, Pa.

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Rocky Mountain: Organized, 1944. Headquarters, Denver, Colo. Meets, First Wednesday. President, J. F. Mohan, 2909 Blake St., Denver 2. Secretary, H. C. Kugeler, 2365 Ash St., Denver 7.

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St. Louis: Organized, 1918. Headquarters, St. Louis, Mo. Meets, First Tuesday. President, J. H. Carter, 710 Kew West Ave., Webster Groves 19. Secretary, J. S. Rosebrough, 1014 Arcade Bldg., St. Louis 1.

South Texas: Organized, 1938. Headquarters, Houston, Tex. Meets, Third Friday. President, D. M. Mills, Gray and Crawford, Houston 3. Secretary, L. L. Ladewig, Box 1188, Houston 1.

Southern California: Organized, 1910. Headquarters, Los Angeles, Calif. Meets, Second Wednesday. President, R. A. Love, 6381 Hollywood Blvd., Los Angeles 28. Secretary, John L. Blake, 1700 S. Bedford St., Los Angeles 35.

Southwest Texas: Organized, 1946. Headquarters, San Antonio, Tex. President, F. C. Benham, Jr., 702 S. Flores St., San Antonio. Secretary, L. S. Pawkett, 810 Insurance Bldg., San Antonio 5, Tex.

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Utah: Organized, 1944. Headquarters, Salt Lake City, Utah. Meets, First Wednesday. President, E. V. Gritton, 2470 S. 15th, Salt Lake City 5. Secretary, C. E. Ferguson, 838 Garfield Ave., Salt Lake City.

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Washington, D. C.: Organized, 1935. Headquarters, Washington, D. C. Meets, Second Wednesday. President, H. H. Hill, 470 Woodward Bldg., Washington 5. Secretary, J. G. Muirheid, 2001 New Hampshire Ave., N. W., Washington 9, D. C.

Western Michigan: Organized, 1931. Headquarters, Grand Rapids, Mich. Meets, Second Monday. President, Frank Harlin, Jr., 280 E. 6th St., Holland. Secretary, W. C. DeRoo, 500 E. 8th St., Holland.

Western New York: Organized, 1919. Headquarters, Buffalo, N. Y. Meets, Second Monday. President, G. E. Adems, 39 W. Balcom St., Buffalo 9. Secretary, J. H. Bryce, 88 E. Girard Blvd., Kenmore.

Wisconsin: Organized, 1922. Headquarters, Milwaukee, Wis. Meets, Third Monday. President, M. W. Bishop, 229 N. La Salle St. (Chicago 1, Ill.). Secretary, B. M. Kluge, 1817 S. 66th St., Milwaukee 14.

Student Branch

Texas A. & M. College: Organized 1946. Headquarters, College Station, Tex. Meets, Third Thursday. President, G. H. Jackson, 225 W. Nevada St., El Paso. Secretary T. V. Burns, 2307 Driscoll, Houston 6.

EQUIPMENT DEVELOPMENTS

For your convenience in obtaining more information about any of this equipment, see coupon on this page. Add the new products and companies listed here to your Directory Section which you received in your January 1947 Heating, Piping & Air Conditioning and thus keep your records of sources of supply up to date throughout the year. Single asterisk indicates equipment not listed in Directory Section; double asterisk equipment and manufacturer not listed.

Offers Hot Air Generator for Drying, Other Uses

No. 3529—The "Thag" heated air generator has been designed by Todd Shipyard Corp., Combustion Equipment Div., 81-16 45th Ave., Elmhurst, Queens, L. I., N. Y., to produce hot air of controllable velocity, temperature, quantity, and pressure. Already used extensively for speeding up the drying of ships' motors and engine room machinery which has either been flooded or covered with condensation, the unit is said to be suitable for use wherever the problem of cleaning and drying machinery exists and for numerous other applications in preheating, melting, annealing, dehydrating, hardening, etc.

The Model No. 1 unit weighs about 1200 lb, has overall dimensions of 72 in. high, 26 in. wide, and 35 in. deep. The 5 hp, 3450 rpm motor drives a fan which has a capacity of 1000 cfm at 10 in. SP. The generator is automatically controlled to provide air at 200 to 350 F and may be used to burn gasoline, kerosene, or diesel oil. Other size units are available for capacities up to 10,000 cfm.

Indicator Handles Many Thermocouples

No. 3530—The "Speedomax" indicator is designed for applications where a large number of thermocouple temperatures must be logged in a short time. To read a temperature, the operator turns a key switch marked for the desired thermocouple; the instrument's drum scale spins and stops at the indicated temperature. The manufacturer is Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

In addition to speed, the indicator is said to offer high sensitivity and accuracy, even for low temperatures and short ranges. Switching arrangements can be supplied to meet the needs of practically any application. A single instrument handles more than 100 thermocouples. Heart of the indicator's mechanism is an amplifier unit which uses standard vacuum tubes. The more commonly used ranges for industrial thermocouples can be supplied by the manufacturer.

Wire Grid Holds Filters

No. 3531—A new "Snap-In" holding grid of heavy wire-steel is an important part of the filter bank assembly being produced by the Research Products Corp., 1015 E. Washington Ave., Madison 3, Wis., manufacturers of filters for air conditioning units, furnaces, central systems, and room coolers.

According to the company, no special skill is required to remove the grid which is equipped with rubber friction stops that jam tightly in the frame and hold the filter pad. The unit is designed to simplify filter replacement.

Air Setting Cement Bonds Mortar with Fire Brick and Insulating Fire Brick

No. 3532—A new air setting refractory cement, called "Air Set," designed to combine the essential engineering requirements with the maximum of practical workability required by the brick mason, has been developed and is being marketed by the Armstrong Cork Co., Bldg. Materials Div., Lancaster, Pa.

This new cold setting cement is designed for use as a bonding mortar with fire brick and insulating fire

Heating, Piping & Air Conditioning [9-47]
6 N. Michigan Ave., Chicago 2, Ill.

Please ask the manufacturers to send me more information about the equipment mentioned under the following reference numbers in Equipment Developments and Recent Trade Literature.

3529	3530	3531	3532	3533	3534	3535	3536	3537	3538
3539	3540	3541	3542	3543	3544	3545	3546	3547	3548
3549	3550	3551	3552	3553	3554	3555	3556	3557	
6622		6624	6625	6626	6627	6628	6629	6630	6631
6632	6633		6635	6636	6637	6638	6639	6640	6641
6642	6643								

Name..... Title.....

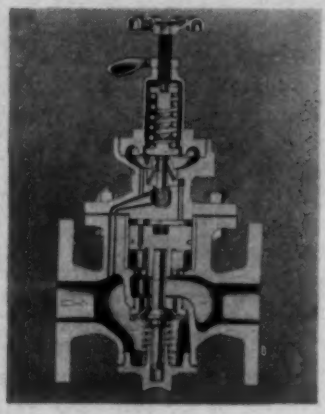
Company .....

Address .....

City..... Zone..... State.....

brick. It is also recommended as a protective facing for fire brick or insulating fire brick furnace linings. It is said to reduce maintenance costs because it provides a tight, permanent joint and strong bond that does not allow brick to become loose in the wall and protects the furnace lining. Outstanding features, says the manufacturer, include workability, high plasticity, and the ease with which it may be poured and thinned with water.

Unloading Valve Controls Inlet Pressure



No. 3533—A throttling type unloading valve, class UL, for use with steam, air, or gas has been announced by Leslie Co., 51 Delafield Ave., Lyndhurst, N. J., manufacturers of pressure and temperature regulators and controllers, strainers, and whistles. This valve is designed for use wherever a throttling type regulating valve is required to maintain a constant inlet pressure by relieving the excess to a lower pressure system.

A feature of the operation is said to be smooth throttling control during the entire cycle of operation with quick action under sudden pressure variations. Construction features include a high pressure bronze body, renewable wearing parts, hard surfaced seat ring, hardened stainless steel main and controlling valves, a bronze piston, corrosion resistant piston rings, and a phosphur bronze diaphragm.

The valve is available in sizes from ½ to 4 in. for inlet pressures from 25 to 300 psi, inlet temperature to 550 F, and a pressure difference not less than 15 psi.

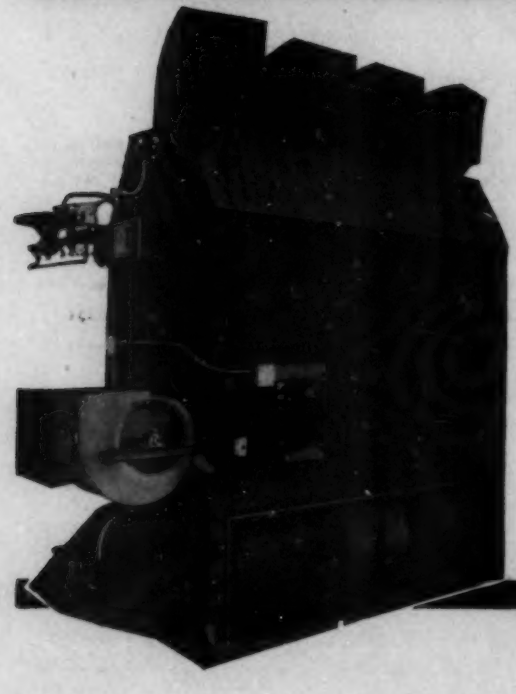
Adjustable Pulley Locks on Shaft by Wedging

No. 3534—A new "Spiralok" fixed adjustable, variable pitch v belt pulley, now being manufactured by Scientiae Corp., 103 Pine St., Dayton 2, Ohio, locks onto the shaft with which it is used by means of a spiral wedging action. No set screws, threads, or keyways are used on the shaft.

The pulley is said to be held in rigid alignment when locked on the shaft so that an infinite number of adjustments may be made. It will drive in either direction of rotation and is designed for use with air conditioning, refrigerating, and ventilating equipment; air compressors; conveyors; machine tools; motor-driven pumps and other motor-driven, v belt connected apparatus.

AIRTHERM
DIRECT-FIRED
WARM AIR HEATERS

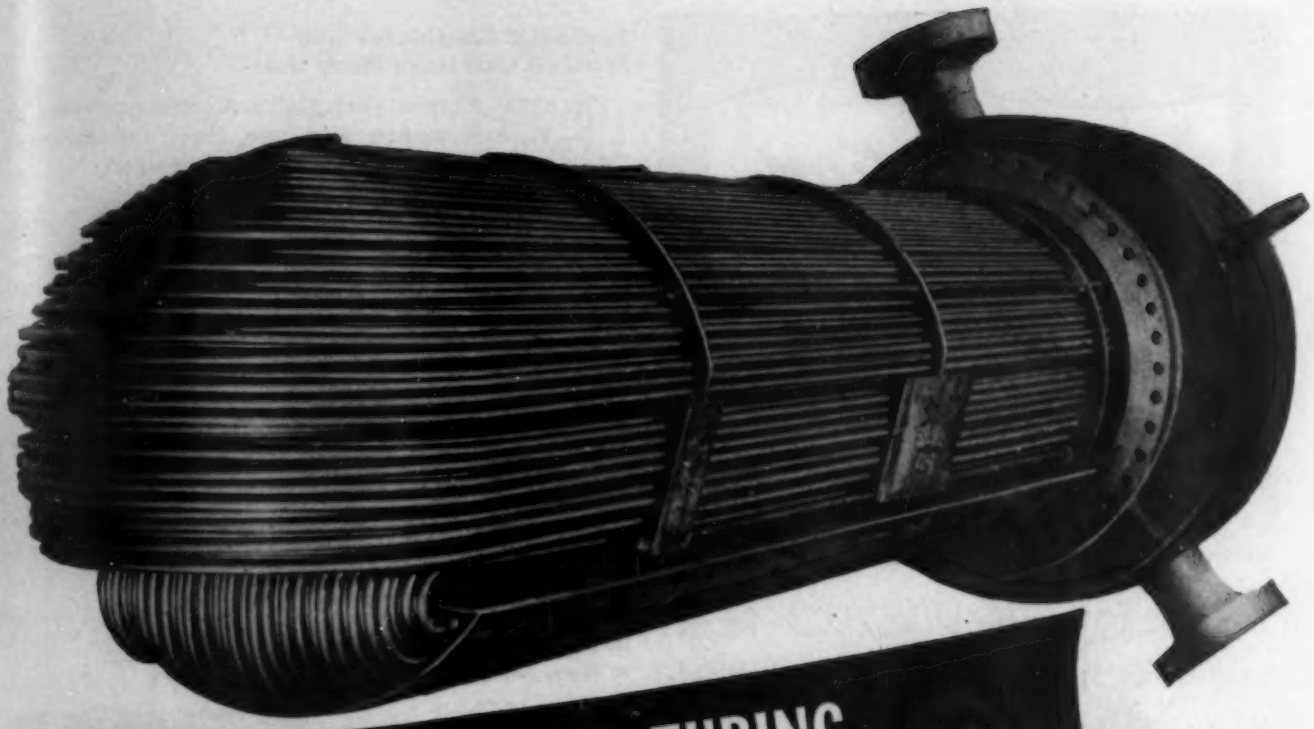
Offer You These Six Heating Advantages



1. A complete factory heating unit.
2. Comes to you ready to set in place.
3. Control system wired at factory.
4. Available in floor-mounted or suspended models.
5. Oil burners or gas burners are interchangeable to meet future fuel conditions.
6. Capacities from 650,000 to 1,950,000 BTU per hour.

For detailed information, write for Bulletin 801-A.

AIRTHERM
MANUFACTURING CO.
711 South Spring Ave. • St. Louis, Mo.



0.065" WALL TUBING HANDLES FEEDWATER AT 1300 P.S.I.

Here's another example of how Monel* helps solve the problems created by soaring temperatures and pressures in modern power plants...

Griscom-Russell Company's Massillon, Ohio plant built this new final-stage preheater for a tube working pressure of 2000 p.s.i., using No. 16 B.W.G. (0.065" wall) annealed Monel tubing of 3/4 inch outside diameter.

This thin-walled, corrosion-resistant Monel tubing permits preheating 439,000 pounds of feedwater per hour, from 345° to 410° F., with steam bled into the shell at 675° F. Boiler operates at 915° F. and 1225 p.s.i.

Strength of Monel greatly exceeds that of other non-ferrous tubing materials, thus permitting thinner tube walls and larger inside diameters. Result is good heat transfer with minimum pressure drop.

Even at elevated temperatures, Monel resists corrosion and offers a smooth, clean surface that retards formation of heat-obstructing jackets of scale and deposits.

In addition, Monel's hardness resists erosive wear, and its ductility allows expanding the tubes into snug-fitting, durable connections with the head.

The extraction heater above . . . actually a repeat order from the Narragansett Electric Company, Providence, R. I. . . . confirms the high efficiency of a similar Monel-tubed unit serving their Manchester Street Station since 1941.

• • •

Other installations of Monel tubing in high-pressure power stations:

At the Twin Branch plant of Indiana and Michigan Electric Company, subsidiary of the American Gas and Electric Service Corp., Monel tubing was installed in a preheater handling 550,000 pounds of water an hour at 3200 pounds pressure per square inch—under external temperature of 637° F.—feeding a boiler operating at 2500 pounds steam pressure!

In the Oswego plant of the Central New York Power Corp., Monel heater tubing was installed to operate under 2000 pounds water pressure, at an outside temperature of 770° Fahrenheit.

If you have problems involving metals for equipment now in production or planned, consult INCO Technical service . . . make use of the wide experience of our engineering staff. Write:

THE INTERNATIONAL NICKEL COMPANY, INC., *67 Wall Street, New York 5, N.Y.*

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MONEL • "K"* MONEL • "S"* MONEL • "R"* MONEL • "KR"* MONEL • INCONEL* • NICKEL • "L"* NICKEL • "Z"* NICKEL

*Reg. U.S. Pat. Off.

Fast Action

PIPE CUTTING IN TIGHT PLACES

RIDGID No. 42 has 4 cutting wheels for easy work in tight quarters

Regular heavy-duty RIDGID cutters in 5 sizes to 6" pipe.

● Short handled for close quarters, this 4-wheel RIDGID cuts pipe fast even where you have room only for a quarter turn. Special malleable housing is distortion-proof; heavy-duty cutter wheels roll easily through toughest pipe—always cut true, leave practically no burr. You'll like this efficient work-saver. Ask for RIDGID No. 42 (½" to 2") or No. 44 (2½" to 4") at your Supply House.

RIDGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY • ELYRIA, OHIO

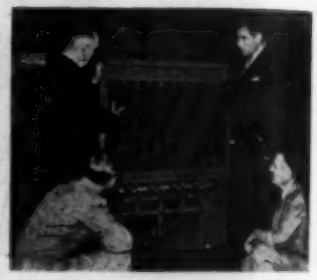
Packaged Conditioner and Window Unit Have Many Uses

No. 3535—Carrier Corp., 302 S. Geddes St., Syracuse 1, N. Y., has announced a new three ton packaged "Weathermaker" and a new self-contained, ¾ ton capacity, window type room air conditioner.

The new conditioner, designated as the 50T4, is designed for use in small stores, office suites, and homes. It has a compressor-motor assembly on a spring-mounted base, with a two cylinder "Freon-12" compressor direct-driven by a 3 hp heavy duty motor. The unit contains an adjustable thermostat for the automatic control of room temperatures as well as a three position, manual switch, so that the air circulating fan can be operated independently.

The new room air conditioner, Model 51G2, is 26 in. wide but is equipped with side wing adapters and seal strips which allow installation in windows up to 40 or even 60 in. in width. It has a sealed, "Freon-12" compressor assembly using a ¾ hp motor.

Heat Output Modulated in New Duct Furnace



No. 3536—The newest addition to the line of gas heating equipment offered by Pacific Heater Div., Naco Mfg. Co., Box 310, Huntington Park, Calif., is a duct furnace incorporating "Duo-Stage" temperature modulation.**

Available in five capacities with outputs from 72,000 to 360,000 Btu per hr, the three larger models utilize the two stage heat input. Modulation is accomplished by thermostatically cutting off gas to some of the individual burners. This is said to provide automatic selection of two stages of discharge air temperature. Units are designed for residential, commercial, and industrial applications and may be installed either singly or as a battery.

Miniature Thermostat Carries Heavy Loads

No. 3537—Designed for applications calling for a miniature thermostat with great load-carrying capacity, the new "Master Mite" thermostat is rated for use up to 1500 watts at either 110 or 220 volts, a-c. It is furnished preset by the manufacturer up to a temperature range of 550 F, and it is available either normally closed or opened. It is offered by Mechanical Industries Production Co., 213 Ash St., Akron 3, Ohio.

Chief among its advantages is said to be a substantially improved accuracy of operation even under extreme overshooting or undershooting of temperature; accomplished by a new design feature permitting a firm but cushioned pressure upon the points. Exceptionally long point life is also claimed by virtue of a slight wiping action of the ¼ in. silver points. This new unit is jacketed in aluminum, copper, or nickel and is insulated with sili-

con-impregnated "Fiberglas." It is designed to be moistureproof, dustproof, tamperproof, and adaptable to immersion in liquids.

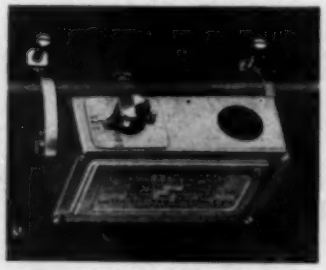
Classed as a heavy duty miniature thermostat, it is offered for application in the electrical and industrial field for air conditioning and refrigeration equipment, motor protectors, vulcanizers, and many electrical appliances.

Repairs Leaks in Metal

No. 3538—"Metalon" is a combination of metals in powder form which is mixed with a special liquid. The resulting paste is applied to repair leaks in all types of pipes, radiators, furnaces, cylinders, boilers, etc. It will be offered through regular retail outlets by Metalon Mfg. Corp., Bayonne, N.J.**

Said to be equally effective on all metals including brass, iron, aluminum, copper, lead, tin, and babbitt, the material hardens in less than 30 min after application. According to the manufacturer, it is steam, heat, pressure, and waterproof and resists the effects of gasoline, oil, and most chemicals.

Strap-On Thermostat Has Bimetal Thermal Element

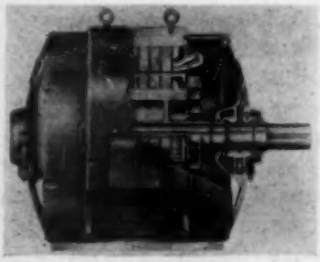


No. 3539—United Electric Controls Co., 69-71 A Street, Boston 27, Mass., has announced a new strap-on thermostat, designated as Type S, which is designed especially for controlling temperatures of water, steam, chemicals, etc. within a differential of 15 deg.

The bimetal thermal assembly is actuated by heat transferred through the rear of the thermostat housing. The dial adjustment is calibrated from 40 to 210 F. Voltage rating is 110 to 220 a-c; wattage is 1200 resistance, 300 inductive. It is said to be suitable for pilot duty operation and to be ideal for many industrial applications.

Three types of switch action are available: (1) normally closed, makes on falling temperature; (2) normally open, breaks on falling temperatures; (3) double throw, one side normally closed, one side normally open, no neutral position.

Large Induction Motors Have Dripproof Construction

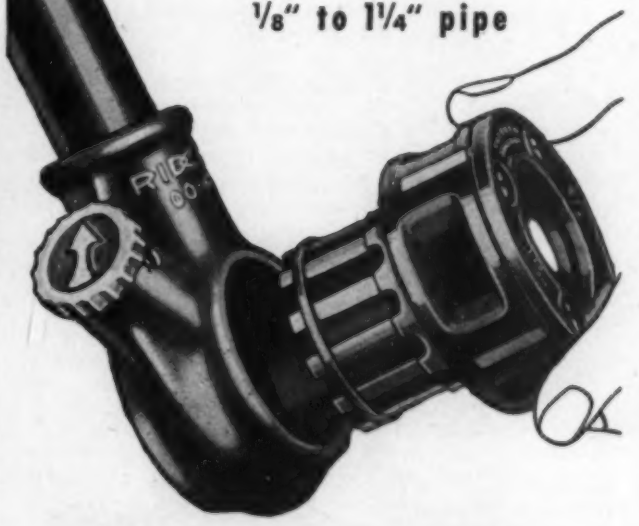


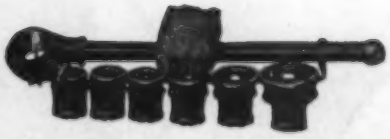
No. 3540—A new line of "Heavy-Duty" squirrel cage induction motors featuring dripproof and splashproof construction has been announced by Electric Machinery Mfg. Co., Minneapolis 13, Minn. Motors are designed for 100 to 1000 hp at 1800 rpm and slower speeds.

According to the manufacturer, the sealed bearings can be cleaned and refilled without motor disassembly. Double end ventilation is provided by a blower on each

Easy Speed
WHEN YOU THREAD
SMALL PIPE

RIGID Nos. 00R and 111R
make short work of threading
1/8" to 1 1/4" pipe



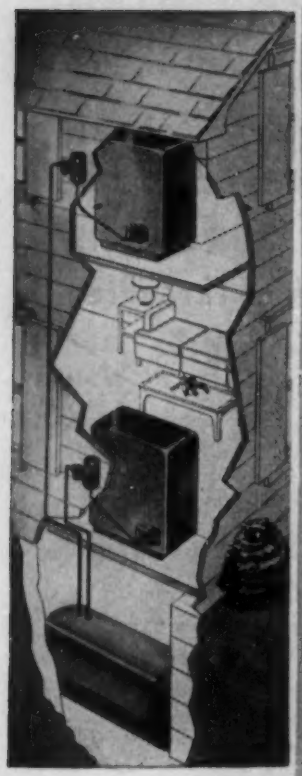


Free handy carrier for any group of sizes.

● Ready to cut smooth perfect threads in a jiffy—just snap the size die head you want into the ratchet ring from either side; can't fall out. No special dies needed for close-to-wall threads. Rugged steel-and-malleable construction, long service heat-treated tool-steel dies. No. 00R, 1/8" to 1"; No. 111R, 1/8" to 1 1/4." Save time and work—buy these smart handy tools at your Supply House.

RIGID
WORK-SAVER PIPE TOOLS
THE RIDGE TOOL COMPANY · ELYRIA, OHIO

For Quick Fall Sales



...INSTALL A-P OILIFTER IN ALL VAPORIZING TYPE OIL HEATERS

Moves Oil from Basement to Burner Automatically

- Ends Oil Handling in the home.
- Eliminates need for fuel tank on appliance.
- Saves Time and Oil on *ANY* Vaporizing Oil Burning Heater, Furnace, or Range.
- Lifts Oil 25 feet high or 100 feet horizontally from bulk storage tank to appliance.
- Easy to Install — Only Single ¼" copper tubing required. No return line.
- Capacity, 1¼ Gallons per hour, sufficient for more than one appliance.
- *PAYS FOR ITSELF IN LABOR-SAVING, FUEL-SAVING, MORE CONVENIENT HEATING.*

Your customer starts the OILIFTER in the Fall—and forgets all about messy "bucketing" of oil between bulk tank and heater. No more oil carrying, no spilling waste of oil, no dripping on floors or rugs. The A-P OILIFTER does this task AUTOMATICALLY, from basement or outdoor tank to first, second, even third floors.

A-P OILIFTER with Filter Unit. Can be installed on ANY vaporizing burner appliance requiring oil flow up to 1¼ gallons per hour.

Sell the A-P OILIFTER to your old customers — and as extra equipment on new heater sales! You'll build greater enthusiasm for oil heating, increased satisfaction and good will — and greater profits. Send today for sales bulletins and full information.

• • •

FOR: HOMES • TOURIST CAMPS • STORES • SCHOOLS • GARAGES • CHURCHES • HALLS

AUTOMATIC PRODUCTS COMPANY

2460 North Thirty-Second Street • Milwaukee 10, Wisconsin

DEPENDABLE *Oil Controls*

DESIGNED TO ELIMINATE SERVICING

end of the rotor. Starting characteristics are NEMA Class B (normal torque, low starting current) for across-the-line starting.

Sheet Metal Brake Has Detachable Stand

No. 3541—A new portable sheet metal brake, the "Webco," is now being manufactured by Webb Machine and Tool Co., Imperial, Pa. Available in working widths of 31 and 49 in., the brakes are designed to handle 20 gage material. Both models come equipped with detachable stand.**

The folding bar is controlled by case-hardened cams resting on leveling washers that are said to permit even distribution of pressure and the bar raises automatically when pressure is relieved, and can be completely removed for bends that cannot be made with fixed bars. Bends up to 150 deg, including the Pittsburgh bend, are made.

Develops Welding Electrode for Low Alloy Steels

No. 3542—For welding low alloy cast steel or low alloy high tensile strength rolled steels in the flat position, with a-c or d-c straight polarity, the DH-MO electrode, available in four diameters from 5/32 to ¼ in., has been announced by Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

This electrode is designed for high speed welding of grooved joints, positioned fillets and horizontal fillets. Welds are said to meet the requirements of AWS-ASTM tentative specifications for Iron and Steel Arc Welding Electrodes classification E-7020.

Relay for Single Phase Motors Externally Mounted

No. 3543—The Bulletin 109 relay developed by Ward Leonard Electric Co., Mount Vernon, N.Y., is designed for use with single phase a-c capacitor motors for oil burners, refrigerators, and other applications.

Positive and reliable motor performance is said to be assured and external or remote mounting of the relay is permissible. Essentially this unit is a potential device operating over a wide range of voltages. Chatterless relay operation down to the dropout point is claimed by virtue of the magnetic circuit design. Contacts are single pole normally closed suitable for operation of a load as large as a 1 hp, 115 or 230 volt, 60 cycle capacitor motor.

Portable Induction Heater Has Many Uses

No. 3544—A new Model UP portable induction heater, manufactured in units of 10 kva for preheating and normalizing for welding, has been announced by Electric Arc, Inc., 104 Jelliff Ave., Newark 8, N. J., manufacturers of Smith-Dolan low frequency induction heating equipment.

The heater was developed primarily to provide flexibility and adaptability to a wide range of applications and capacities. According to the manufacturer, a minimum amount of equipment is necessary. The individual units of 10 kva each may be stacked on the job to form groups of two and three units with capacities of 20 and 30 kva, to obtain sufficient heater capacity for preheating and normalizing welded joints on pipes of larger diameters. The 30 kva group, for instance, is said to be capable of preheating a 10 in. pipe joint to 1300 F in 2 hr.

In addition to preheating and normalizing welds, the heaters are offered for thawing large water lines, resistance heating for brazing and soldering, shrink-fitting, heating for straightening, drying water soaked rotors and stators, and many other such uses.

Thermostat Designed for Unit Heaters

No. 3545—Barber-Colman Co., Rockford, Ill., has announced a new thermostat designed for unit heater applications. It is a line voltage unit which has a heating range of 40-80 F, a cooling range of 55-95 F, and is offered for commercial, industrial and domestic service.

Designed for normal duty ¼ hp at 115/230 volts, a-c, the thermostat has snap-acting SPST contacts and a mounting plate designed to fit a standard outlet box, surface or flush type.

Condensate Return System Used for High Differential Service

No. 3546—To accomplish the return of condensate to higher pressure boilers from presses, dryers, and other steam heated process equipment, Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia 32, Pa., has announced development of the new "CBA" high pressure condensate return system.

This new unit is designed to give added capacity with lower horsepower motor ratings. Lower pressure condensate can be returned direct to boilers in the 100 to 150 psi range than was formerly possible. For example, a standard 5 hp unit will handle 15 gpm at 50 psi differential and a 5 hp unit will handle the same

Serving the City of
QUITO, ECUADOR

In Quito, Ecuador, almost astride the equator at an elevation of over 9 thousand feet, 5 Layne Well Water units are now producing 2,280,000 gallons of water per day. Highly pleased with the proven efficiency, low operating cost and outstanding quality. Quito's city officials have just ordered another 5 Layne Wells and Pumps for another section of the city.

Designed and installed by U. S. trained engineers, Quito's completed Well Water Supply will be equal in every way to the finest on the North American Continent.

Layne Well Water Systems are universally favored the world over. They are designed and built to give the utmost in long life and operating satisfaction. Layne has many such installations in the Latin American countries, all of which are fully measuring up to their reputation of high efficiency and low operating cost.

If your city, railroad, factory, packing plant, ice plant, or irrigation project is in need of more water where production cost per million gallons must be extremely low, you should have complete facts about Layne Well Water Systems and Layne Vertical Turbine Pumps. For literature, address

LAYNE AND BOWLER, INC.
General Officers, Memphis 8, Tennessee

• **pumps** for wells, lakes, rivers, reservoirs, irrigation —or for any use where large quantities of water must be produced at low cost. Sizes range from 40 to 16,000 gallons per minute. Write for Layne Pump Catalog.

LAYNE WELL WATER SYSTEMS
vertical turbine pumps

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. • Layne-Atlantic Co., Norfolk, Va. • Layne-Central Co., Memphis, Tenn. • Layne-Northern Co., Mishawaka, Ind. • Layne-Louisiana Co., Lake Charles, La. • Louisiana Well Co., Monroe, La. • Layne-New York Co., New York City • Layne-Northwest Co., Milwaukee, Wis. • Layne-Ohio Co., Columbus, Ohio • Layne-Pacific, Inc., Seattle, Washington • Layne-Texas Co., Houston, Texas • Layne-Western Co., Kansas City, Mo. • Layne-Western Co. of Minnesota, Minneapolis, Minnesota • International Water Supply Ltd., London, Ontario, Canada • Layne-Hispano Americana, S. A., Mexico, D. F.

PATTERSON-KELLEY
Heat Exchangers
AND
Process Equipment

Heat-Transfer
SPECIALISTS

Specializing
IN REFRIGERANT
COOLERS

The very essence of "air conditioning" is the controlled transfer of heat.

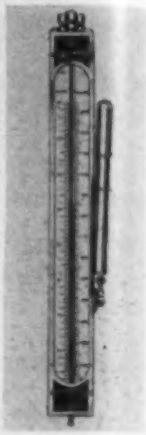
It was entirely logical, therefore, that Patterson-Kelley engineers, who have specialized for years in heat-transfer equipment, should turn their attention years ago to refrigerant coolers, condensers and other heat-transfer equipment needed in air conditioning and refrigeration systems.

Today, Patterson-Kelley Equipment, coolers for example, is considered by many to be the standard for such installations.

EST 1906
THE PATTERSON-KELLEY Company, Inc.
107 WARREN STREET, EAST STROUDSBURG, PA.
NEW YORK 17—101 Park Ave. PHILADELPHIA 3—1700 Walnut St.
CHICAGO 4—Railway Exch. Bldg. BOSTON 16—96-A Huntington Ave.
Representatives in Principal Cities

quantity at 150 psi differential. The essential engineering features of the system are said to insure thorough condensate and air removal from process apparatus, making increased production possible by maintenance of uniformly high temperatures.

Remote Gage Measures Liquid Level in Tanks



No. 3547—The new Type S "Tank-O-Meter," for measuring the contents of a tank at any remote point whether the tank is vented, closed, under pressure, or under vacuum, has been announced by Uehling Instrument Co., 473 Getty Ave., Paterson 3, N.J.

The unit is available with high or low alarm switches for controlling any circuit at any predetermined high or low level and 52 models are offered for measuring liquid depths from 1 to 75 ft. Operation is obtained either by hand pump or compressed air.

Uses Fan in Roof Ventilation

No. 3548 — A straight - through type of powered roof ventilator, the "Ject - O - Valve," uses a propeller type fan to exhaust heat, smoke, fumes, etc. through a divided top which opens and closes automatically. The manufacturer is the Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.

The unit, available in five sizes and in a wide range of capacities, is said to be weather-tight at all times.

Develops Electrode for Light Gage Welding

No. 3549—The A. O. Smith Corp., 3533 N. 27th St., Milwaukee 1, Wis., has announced the manufacture of a new welding electrode, the SW-16, for light gage welding in the sheet metal field.

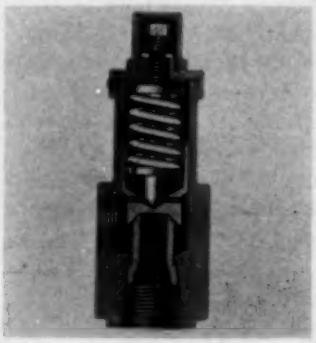
It is a high speed, heavy coated electrode for all position welding on mild steel of light gage and is said to weld with a minimum build-up and to produce a bead contour that requires little finish grinding. The welding characteristics are designed to guard against bead sagging and burning through.

Direct-Fired Air Heater Has Diagonal Heating Tubes

No. 3550—Round, diagonally placed air heating tubes located directly over the fire is the design feature in the line of direct-fired air heaters offered by the Johnson Heater Corp., 12 Newhall Ave., Saugus, Mass. The all welded units are offered in capacities from 123,000 to 5 million Btu per hr.**

According to the manufacturer, the double banks of crisscross tubes provide unusually high heat transfer so that the dimensions of large capacity units are relatively small. The heaters may be fired with either oil, gas, or by stoker, and are said to be ideal for installations such as in factories, warehouses, and garages.

High Pressure Relief Valve Made of Bar Stock



No. 3551—Farris Engineering Corp., 494 Commercial Ave., Palisades Park, N. J., has introduced a new and simplified relief valve, Model No. 2745, for pressures up to 10,000 psi. The valve is fabricated completely from bar stock, either bronze, cold rolled steel, or stainless steel, depending on the service for which it is intended. In all valves the disc and nozzle are of stainless steel.

Available with or without test gear in body sizes of ½, ¾, and 1 in., the valves have interchangeable nozzle inserts to provide for proper capacity at set pressures in ranges of 2000, 5000, and 10,000 psi for each size. This versatility is designed to permit application in a wide variety of services.

Exceptionally high flow efficiency, with a coefficient approximating unity, is claimed by virtue of the high lift of the disc (brought about by the high kinetic energy of the discharge developed by the venturi action of the nozzle).

Color Matching Used in Oil Burner Smoke Indicator

No. 3552—The Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Pa., has developed a new instrument designed primarily for testing density of smoke from the combustion process in oil burning furnaces. The device consists of a sampling unit attached to the smoke pipe of the oil burning furnace, a motor driven vacuum pump and a time switch mounted on the motor base which stops the operation of the motor after a 1 min interval.

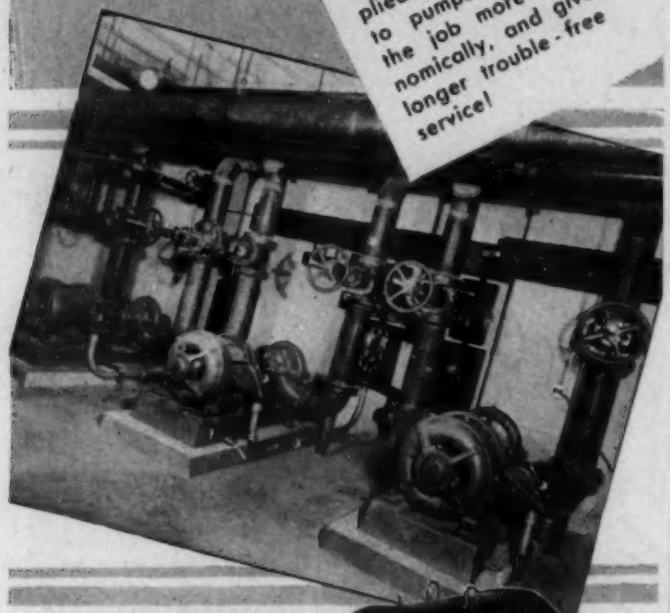
The vacuum pump draws flue gas from the sampling tube through a filter disc for one minute at a controlled vacuum. The smoke is carried along in the flue gases sampled and is deposited on a filter disc, thus producing a visual indication of the smokiness of the flame. The filter disc is removed from the holder and matched with smoke discs on a comparator scale. In this way, says the manufacturer, it is a simple matter to adjust an oil burner to give the highest percentage of CO_2 without objectionable smoke.

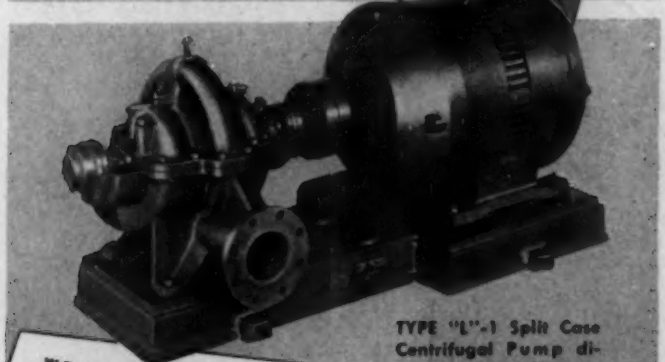
ADSCO
TYPE "T" STEAM
TRAPS
The Most Convenient Trap Available
VALVE AND FLOAT MECHANISM MOUNTED ON COVER
No need to touch piping while cleaning
NON-CORROSIVE STAINLESS STEEL VALVE AND SEAT REVERSIBLE FOR DOUBLE LIFE
COMPACT, LARGE CAPACITY
CONVENIENT PIPING
FOR ALL STEAM PRESSURES
AMERICAN DISTRICT STEAM CO
NORTH TONAWANDA N.Y.

proven dependability

● You can always judge a pump by the company it keeps! That's why it's so significant that WEINMAN CENTRIFUGAL PUMPS will always be found, hard at work, whenever the job calls for day in and day out DEPENDABILITY! Weinman pumps are designed and engineered by Centrifugal Specialists who KNOW THE AIR CONDITIONING FIELD, and have applied this knowledge to pumps that do the job more economically, and give longer trouble-free service!

Three Type L-1 Weinman Pumps in the 4,902,196 cu. ft. Air Conditioning Plant of the F. & R. Lazarus & Co., Columbus, Ohio . . . Central Ohio's largest department store.





TYPE "L"-1 Split Case Centrifugal Pump direct-connected to motor. Capacities of 160 GPM to 3,500 GPM . . . heads to 230 ft. Write for bulletin No. 627-2

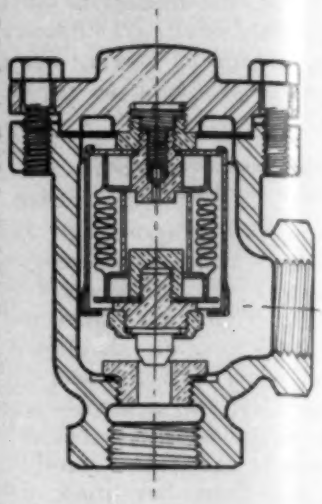
WRITE, WIRE, OR PHONE FOR ANY INFORMATION ABOUT PUMPS OR PUMP INSTALLATIONS . . . IT'S FREE SERVICE!

Built by Centrifugal Specialists

The WEINMAN Pump Mfg. Co.

COLUMBUS · 8 · OHIO

Thermostatic Trap Handles Corrosive Condensate, High Pressures

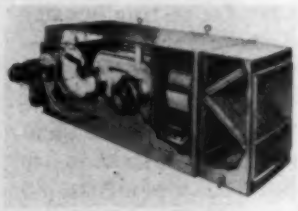


No. 3553 — Sarco Co., Inc., 475 Fifth Ave., New York 17, N. Y., is now making cast steel, thermostatic steam traps with patented helical bellows. They are designed to withstand the shock of external explosions such as occur in oil refineries and chemical plants, to handle corrosive condensate, and to operate with pressures to 300 psi or with superheat.

The cast steel body and cap are designed to the strength necessary to withstand the shocks of external explosion. The stainless steel thermostatic element is said to handle corrosive condensate and permit these traps to be used for superheat or for a maximum operating pressure to 300 psi. Another of this series has a bronze thermostatic element for maximum operating pressures to 225 psi saturated steam. The thermostatic element is a patented helical bellows which is said to permit a larger orifice than can be provided on float or bucket traps. The greater air venting capacity is said to provide rapid heating from a cold start.

According to the company, there are no seats to change for pressure changes or fluctuations because the differential between the pressure created in the thermostatic bellows and the steam pressure remains practically constant. When installed to discharge to the atmosphere, no protection is required against freezing.

New Furnace Saves Floor Space



No. 3554** —The new "Superfex" Model 550 suspended oil furnace has been developed by Perfection Stove Co., 7609 Platt Ave., Cleveland 14, Ohio, for use in such establishments as service stations, garages, supermarkets, hangars, small factories, warehouses, stores, and any business which has a large, open space to be heated and where floor space is at a premium.

Light in weight (only 650 lb), the unit can be suspended from existing ceiling beams or girders without additional structural support. It is automatic in operation and a new axial flow blower provides forced circulation of air. When the thermostat has been satisfied, the blower drops back to low speed and continues to utilize all of the heat in the furnace, distributing it throughout the area to be heated.

No. 3 fuel oil is drawn to the burner from an outside storage tank, either buried underground or placed atop

the ground, by means of a heavy duty, two stage fuel pump on the burner. The unit has a rated output of 200,000 Btu per hr and is equipped with air filters.

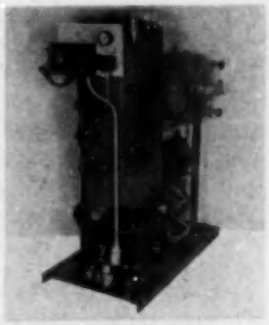
Develops Glass Insulation for High Temperature Use

No. 3555—Owens-Corning Fiberglas Corp., 718 Fifth Ave., New York 19, N. Y., has developed a line of lightweight, high temperature insulating materials, in felt and bulk form, designed to withstand temperatures up to 1800 F.

Composed of specially processed filaments of glass, the new line is designed for industrial, marine, and aircraft applications where a need exists for a flexible, removable type of insulation that will withstand physical deterioration at extremely high service temperatures.

In felt or bulk form, the new materials are said to be suitable for insulating housings and flange covers of high temperature steam turbines, and exhaust manifolds and turbo-supercharger housings on oil or gas-fired supercharged 4-cycle diesel engines. They can also be employed as the filtering element in fly ash separators used in high temperature processing equipment.

Steam Boiler Shipped As Package Unit



No. 3556—A small packaged steam boiler, built in accordance with the ASME boiler code and in various sizes from 2 to 30 hp, has been developed by Alert Engineering Products, 315 W. Woodbridge St., Detroit 26, Mich.**

The unit is shipped with all controls in place and all interconnected wiring and piping finished. The boiler includes a condensate return system with motor, pump, tank, and float valve. Feedwater, pressure, and safety controls are furnished together with a gas burner or oil burner. The unit is said to require very little floor area and to be suitable for many industrial and commercial uses. It is also available in nonautomatic or standard units.

Develops Adhesive Technique for Joining Nonporous Surfaces

No. 3557—Samuel Cabot, Inc., Oliver Bldg., Boston 9, Mass., has developed "Plasgon Sandwich Adhesion" for joining metals, rubber, glass, plastics, and other nonporous surfaces.

The material is spread over each surface, and a layer of selected fabric is inserted between. This "sandwich," with the fabric in the center, is pressed firmly together and allowed to set for 48 hr. The result is said to be a tough, flexible joint, proof against oil, gas, kerosene, water, and other common solvents. According to the manufacturer, no special heating, thinning, or treatment is required in making the joint which will withstand a shear stress of over 200 psi.

Sheehan and Krech, Designers and Builders
Air Conditioning by Schwerin Air Conditioning Corporation

Simply designed air diffuser blends with interior

Provides complete air conditioning comfort by eliminating drafts, noise, hot or cold spots.

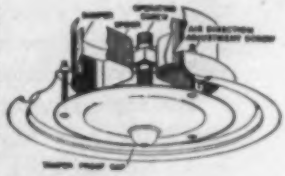
In addition to their unobtrusive appearance, Kno-Draft Adjustable Air Diffusers are specified for installations like the one pictured here in the offices of Schwarzenbach-Huber Co. because they combine all the advantages of scientific air diffusion plus adjustable features which assure positive air pattern control.

Kno-Draft adjustability increases efficiency and economy.

Diffusers improve occupant comfort by delivering conditioned air gently and thoroughly. Drafts and noise so often experienced with grilles, registers and other louvered devices are eliminated. Economy is increased. Diffusers handle greater air velocities and greater temperature differentials. This means less air volume, smaller, simpler ducts and fewer outlets.

To those advantages, Kno-Draft adds adjustment features that increase both the efficiency and economy of the air diffusion principle and a simplicity of design that blends with any interior.

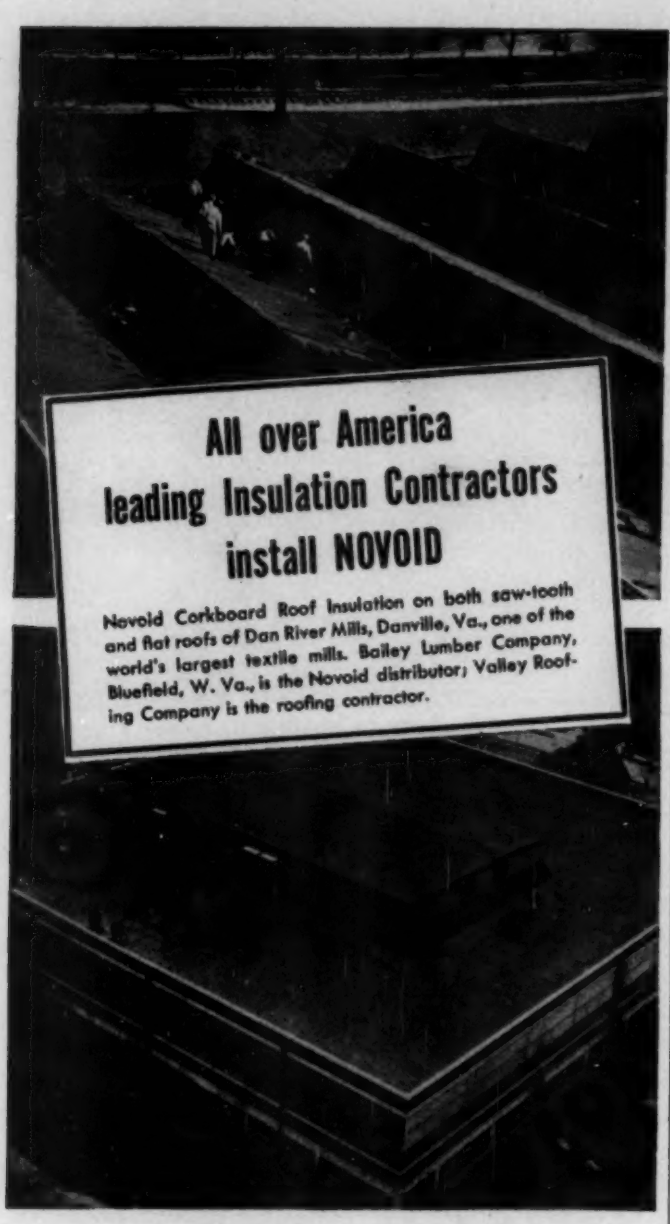
Kno-Draft Direction Adjustment assures positive air pattern control by affording any angle of air discharge from vertical to horizontal that is needed to accommodate ceiling heights, individual or seasonal requirements. Volume adjustment is made with a patented damper that regulates the amount of air without affecting the velocity or diffusion pattern.



Pat. & Pat. Pending

Send for FREE handbook that simplifies the selection and installation of diffusers. Write Dept. D-13 on your letterhead.

W. B. CONNOR ENGINEERING CORP.
AIR DIFFUSION AIR PURIFICATION AIR RECOVERY
112 East 32nd Street CONNOR **New York 16, New York**
IN CANADA: Douglas Engineering Co., Ltd., 1405 Bishop St., Montreal 25, P.Q.


All over America
leading Insulation Contractors
install NOVOID
Novoid Corkboard Roof Insulation on both saw-tooth and flat roofs of Dan River Mills, Danville, Va., one of the world's largest textile mills. Bailey Lumber Company, Bluefield, W. Va., is the Novoid distributor; Valley Roofing Company is the roofing contractor.

To give satisfaction on a roof job, insulation must be efficient, light in weight, resistant to absorption of moisture and pitch, resilient, strong, and permanent. Severe requirements —but Novoid Corkboard meets them unusually well. Firms which have installed it on their roofs consistently reorder Novoid for new construction.

The same advantages make Novoid Corkboard ideal for insulating cold rooms—and make Novoid Cork Covering the best choice for low-temperature lines. Consult your local insulation contractor about Novoid insulations, or write direct to Cork Import Corporation, 39 Park Place, Englewood, N. J.

NOVOID INSULATION

CORKBOARD • PIPE COVERING

Equipment Shorts

New plant facilities at Hornell, N. Y., will provide SKF Industries, Inc., with capacity that will enable this ball and roller bearing firm to achieve an 80 per cent increase in production of pillow blocks at peak operation. Production at this plant, which was scheduled to begin about September 1st, will include two new types of ball bearing unit pillow blocks.

The Armstrong Cork Co. of Lancaster, Pa., is planning to build new laboratories. The new facilities will include latest developments in industrial research, laboratory design, and equipment. In addition to the main building, a large single story pilot plant, several smaller pilot plants, and a boiler house will be built.

The Condenser Service & Engineering Co., Hoboken, N. J., has announced that its Pottsville Division is producing high tensile cast iron castings, such as water boxes, return heads, shells, steam and diesel cylinders, rotary compressor cylinders, and special items. The castings used in the chemical industry are subsequently rubber lined.

In the interest of centering manufacturing facilities on its principal lines, Gardner-Denver Co. has sold its governor business to the Wiebmer Machine Shop of Quincy, Ill. Gardner-Denver will henceforth concentrate on producing rock drills, air compressors, pumps, and other allied products.

A new 16 mm industrial film, running 17 min, and showing typical applications of "Speed Nuts" to various assembly problems, is offered to all interested industries by Tinnerman Products, Inc., 2038 Fulton Rd., Cleveland 13, Ohio.

The Eutectic Welding Alloys Corp., 40 Worth St., New York 13, N. Y., has announced the availability of "EutecTrodes" 67 AC and 670 DC. These low temperature welding electrodes have a high alloy content developed for joining, filling, filleting, and overlaying all types of steel where high tensile and impact strength, hardness, and wear resistance are required.

A new decilog log slide rule, designed to simplify computation, has been announced by Pickett & Eckel, Inc., 5 S. Wabash Ave., Chicago 3, Ill. The scales on the front of the rule are so arranged that only one setting of the hairline gives with each result its square root, cube root, and logarithm. The log log scale on the back is expanded for greater accuracy and is arranged to give these five readings with each setting of the hairline: (1) decimal fraction to 4 and 5 figures, (2) its reciprocal to 4 and 5 figures, (3) logarithm, (4) cologarithm, and (5) natural logarithm.

EXECUTIVE CHANGES

At a recent meeting of the board of directors, Fred F. Loock, formerly vice president and general manager, was elected president of the Allen-Bradley Co., manufacturers of electric controlling apparatus, Milwaukee, Wis. At the same meeting, Harry L. Bradley was named chairman of the board. Other officers, who were re-elected, are R. W. Whitmore, vice president and works manager; Louis Quarles, secretary; and A. F. North, treasurer.

The appointment of H. C. Hickock as general sales manager of the Baker Ice Machine Co., Inc., South Windham, Maine, has recently been announced. A native of Massachusetts and a graduate of Worcester Polytechnical Institute, he served as a naval officer in World War I and since that time has engaged in a broad field of technical and sales activity. S. F. Smith, Mr. Hickock's predecessor, has resigned to form his own organization to distribute transportation equipment and related specialties.

Harold S. Falk, president of The Falk Corp., Milwaukee, has been elected to the board of directors of Allis-Chalmers Mfg. Co., also of Milwaukee. Mr. Falk, whose firm is widely known as a manufacturer of reduction gears and steel castings and as a large producer of gear units for Navy vessels, also holds directorship in the Heil Co., Northwestern Mutual Life Ins. Co., Wisconsin Electric Power Co., and several other companies. He was awarded the John Penton medal by the American Foundrymen's Association in 1939 and is a member of numerous technical societies and fraternities.

Morris G. Munson has been appointed manager of the unit ventilator division of the Herman Nelson Corp., Moline, Ill., manufacturers of heating and ventilating products. In his new position Mr. Munson will coordinate the activities of all departments of the company to further the development and marketing of its unit ventilator line. He joined the corporation in 1911 and for the past 17 years he has been located in the home office in various executive capacities.

R. W. Shoemaker has established an office at 3533 Oak Knoll Blvd., Oakland, Calif., for the purpose of doing consulting work in the fields of radiant heating and electrical engineering. He is associated with Robert Kruen under the name of Thermo-Radiant Consultants for designing radiant heating and cooling applications, and with Thermo-Panels, Inc., of Oakland, supplier of radiant heating equipment. Mr. Shoemaker has been appointed consulting engineer for the Oakdale irrigation district in connection with the irrigation and power developments on the Stanislaus river, a project of approximately 50,000 kw. For the past 13 years he was a consulting engineer with Chase Brass & Copper Co. and prior to that was engineer for the Turlock and Modesto, Calif., irrigation districts.

for • SPRAYING
• WASHING
• RINSING
• COOLING
• AIR CONDITIONING

YARWAY

SPRAY NOZZLES

FAN-TYPE FOR FLAT SLICING SPRAY

Get the most out of your Spraying Equipment with minimum power . . . with efficient spraying.

Use Yarway Nozzles. No internal vanes or other restrictions to clog or hinder flow. Two types—Yarway Involute-type producing a fine hollow spray with minimum energy loss, and Yarway Fan-type producing a flat fan-shaped spray with time-saving slicing action for cleaning.

Wide range of standard sizes and capacities. Cast or machined from solid bar stock.

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NEW BOOKS & REPORTS

Disinfecting Air in Hospitals Presents Many Problems

Stating that the last word has not been said in regard to air disinfection and that no single method seems to be entirely adequate, "it is highly probable that some combination of ultraviolet barriers, chemical disinfection, and active mechanical ventilation present the best means foreseeable in the light of present knowledge," according to a 21 page bulletin on The Disinfection of Air, published by the American Hospital Association.

The pamphlet consists of a brief report of the association's committee on air sterilization and conditioning and its council on hospital planning and plant operation. After briefly analyzing the methods and procedures currently available and as applied to hospitals, it is concluded that ultraviolet radiation alone is not the complete answer as the burning effects of the ultraviolet rays are such that the immediate area of a wound and of the path between the sources of infection and the lamp cannot be irradiated without taking measures for the protection of personnel that are considered to be impractical. The lower levels of operating rooms, etc., cannot be irradiated because of the explosion hazards when hydrocarbon anesthetics are used. It is also pointed out that theoretically glycolization would furnish a more adequate disinfection but it is questionable if exposure time, while bacteria are in transit to the wound from the respiratory passages of the operating personnel, would be sufficient for full effectiveness. Proper ventilation is considered to be a very effective dust suppression measure.

Copies of this report may be obtained from association headquarters at 18 E. Division St., Chicago 10, Ill., for 25 cents each.

Offers Data on How to Select Low Temperature Insulation

Recognizing the importance of insulation technique in properly planned cold storage, freezing, cooling, air conditioning, and refrigeration operations, the Industrial Mineral Wool Institute has published a new manual, Holding Low Temperatures With Better Insulation.

The booklet, reported to be the first of its kind, gives information on how to select insulation and what to look out for; includes data on forms, properties, and application methods; and a chapter on the principles and significance of vaporproofing for various types of wall, floor, and ceiling construction. The work contains 15 photographs, 11 diagrams, 7 charts and tables, and analyses of typical case history installations.

Particularly helpful to users will be graphs on representative thermal conductivities of various mineral wool forms, a chart for computation of minimum insulation thicknesses to prevent condensation on cold surfaces in various environments, minimum thicknesses and recommended techniques for pipe insulation, data

MASTER FLO-CONTROLS FOR POSITIVE AND ACCURATE MANUAL OR AUTOMATIC FLO-TEMPERATURE CONTROL

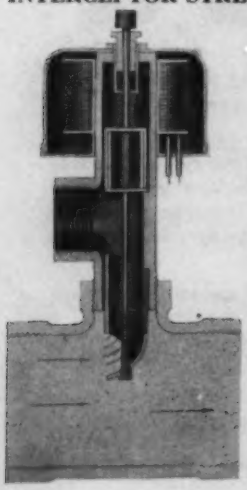
Temperatures as desired can be secured in each separate zone. Zoning of all or parts of panel heating coils, mains or risers can be accurately done with thermostatic operated MASTER ZONE-CONTROLS.

Circulation for temperature balance can be secured throughout the heating system with emersion operated MASTER ZONE CONTROLS.

With the use of MASTER FLO-CONTROLS no changes occur in the pumping head to change the static balance of other branches of the circulating system as takes place with the use of PUMPS FOR ZONING.

MASTER FLO-CONTROLS ARE NOT VALVES

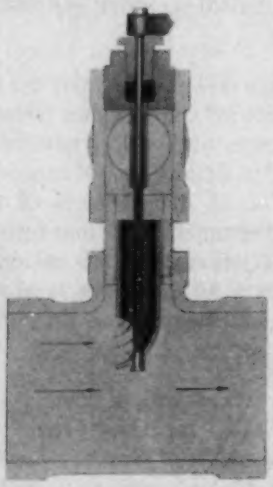
The MASTER FLO-CONTROLS operate with the PATENT MOVING INTERCEPTOR STREAMLINED TUBE that intercepts the flow, directing same without loss through the tube into the branches resulting in 100% diversion with less friction than required for conventional pipe tees.



The MASTER FLO-CONTROLS are not valves or fittings with flat pedal interceptors that allow the flow to slip out over the sides of the interceptors, but are streamlined interceptor tubes.

The ZONE-MASTER regulates the flow thru the streamlined interceptor tube operated by a solenoid or motor under the control of a thermostat or emersionstat.

Flow distribution thru the ZONE-MASTER can be manually adjusted during circulation for balanced temperature circulation.



The FLO-MASTER regulates the flow thru the streamlined interceptor tube by manual adjustment during circulation for balanced temperatures.

Changes in the desired temperatures can be made by manual adjustment during circulation.

•

MASTER FLO-CONTROLS ARE INSTALLED IN CONVENTIONAL PIPE TEES ELIMINATING LARGE STOCKS OF SPECIAL FITTING.

•

MASTER FLO-CONTROLS built with the interceptor streamlined tube ELIMINATES ALL WATER NOISES caused by special fittings with fixed partitions, jet pipes, valve interceptors and other obstructions to the flow of water that result in high circulating pressures.

The W-H Engineering Company

4102 S. La Salle St. Chicago 9, Ill.

on long term storage temperatures for various food products, and recommended procedures for the vapor sealing of masonry, wood, block, and plastered walls.

Copies of the 24 page booklet are available free of charge from the Institute at 441 Lexington Avenue, New York 17, N. Y., or from any of its 16 member companies.

New SMA Manual Includes Data on Smoke Abatement, Automatic Controls

A new, revised, expanded and improved second edition of the Technical Manual published by the Stoker Manufacturers Association containing the industry's standards, recommended practices, codes, and other technical information, is off the press ready for distribution.

Added to the revised and reorganized material republished from the first edition is some new information on the smoke abatement problem (a new section containing the recent SMA publication, Factors Affecting Smokeless Operation of Underfeed Stokers), building requirements and recommendations, automatic controls, and miscellaneous data.

The basic data and text of the industry's standards, codes, and recommended practices remain intact in the new manual except for such revisions and refinements as will clarify and facilitate their use. Included among these improvements are several new or redrawn charts.

The new edition is bound in green paper cover. Convenient thumb tab spacers are used to mark each of the eight sections. The book is 8½ x 11 in., 66 pages. The regular published price is $1.00 per single copy, but special prices in quantity lots will be quoted to members of the trade upon request. Orders and correspondence should be addressed to the Stoker Manufacturers Association, Lloyd L. Connell, Technical Director, 307 North Michigan Avenue, Chicago 1, Ill.

Handbook Includes New Data, Standards on Air and Gas Compressors

The new Compressed Air Handbook is published as a reference text on applications, installation, operation, and maintenance of compressing equipment and air-powered tools of all types. In addition to making available a mass of new and original data not heretofore published in a single volume, the book contains, in revised and improved form, all of the standard reference material formerly published as "Trade Standards." Included are definitions, test standards and numerous basic tables and formulas.

It is said to represent the collective knowledge, experience, and thought of the 19 member companies of the Compressed Air and Gas Institute, and was compiled over a two year period as a joint activity of the Institute's educational and technical committees.

Among the topics treated are typical applications of compressed air and gas; representative types of compressor installations; portable air-operated tools and rock drills; planning, selecting, and installing the compressed air plant; and engineering data and test procedure.

Containing 400, 6 x 9 in. pages and 247 illustrations, the bound book is published by the Compressed Air and Gas Institute, 90 West St., New York 6, N. Y. The price, postpaid, anywhere in the United States is $3.00; elsewhere $3.50.

Semi-automatic

RIDGID No. 65R is ready to thread 1" to 2" pipe almost instantly

● When you have a self-contained No. 65R, there's no fooling around to thread 1", 1¼", 1½" or 2" pipe. Its one set of high-speed steel dies adjust to pipe size easily in 10 seconds. Mistake-proof workholder sets instantly — one screw to tighten, no bushings. Perfect threads quickly, with least effort. Every tool factory tested. More for your money — ask your Supply House for the No. 65R.

It stands up handily on the floor.

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WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY · ELYRIA, OHIO

Here's Your
"Handful of Power"
for Continuous Drilling

A Black & Decker Electric "HOLGUN"* is an easy drill to handle, weighs only three pounds, measures only 6¾" overall. Yet, this compact tool has abundant power for continuous drilling that saves time in all kinds of heating, piping and air conditioning jobs.

Drives twist drills up to ¼" . . . wood augers up to ½" . . . small wire brushes for cleaning and burnishing . . . B & D Hole Saws for cutting clean, round holes up to 1⅛" diameter in any material a hacksaw will cut. Ideal for working in hard-to-reach places. Requires less muscle to operate. Smooth housings, with famous "Pistol Grip and Trigger Switch," fit naturally into either hand.

Black & Decker Electric "SCRUGUNS"* are perfect team-mates for these drills to speed up many sheet metal assembly operations. Shaped just like the HOLGUN. Insure greater accuracy and uniformity with minimum operator fatigue. For full information on HOLGUNS, SCRUGUNS and many other Portable Electric Tools, see your nearby Black & Decker Distributor. Write for free catalog to: The Black & Decker Mfg. Co., 628 Pennsylvania Ave., Towson 4, Maryland.

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Industry Approves Pipe Fitting Standard

The proposed revision of Simplified Practice Recommendation R185-42, Pipe Fittings, has been approved for promulgation, according to an announcement by the division of simplified practice of the National Bureau of Standards. The revised recommendation is identified as R185-47, Pipe Fittings, and has been effective since September 1, 1947.

The revision applies to gray cast iron, malleable iron and brass or bronze fittings, and includes a comprehensive group of fittings required for sprinkler systems, in addition to the regular lines for other purposes. Although it has been found necessary to increase the number of fittings which formerly comprised the simplified list, the items retained still represent a substantial reduction from the number formerly listed.

Printed copies of the revised recommendation were to be ready on or about September 1. If not available, mimeographed copies may be obtained from the division of simplified practice, National Bureau of Standards, Washington 25, D. C.

Other Books and Reports Received

Transient Temperatures Around Heating Pipes Maintained at Constant Temperature, by Andrew Gemant, the Detroit Edison Co. Published in the Vol. 17, No. 12 issue, Journal of Applied Physics. Deals with the transient temperature distribution caused by conduction around cylindrical heating pipes. The theoretical equation for this case is integrated numerically and is presented in graphs.

Short Cuts for Round Layouts, by Joseph Kaberlein, instructor of sheet metal apprentices, Washburne Trade School, Chicago. Contains 269 + xi pp., is cloth-bound, is published by the Bruce Publishing Co., 540 N. Milwaukee St., Milwaukee 1, Wis., and is priced at $3.75. Embracing the variety of joints, transitions, elbows, stacks, etc., found in round duct work, this text is designed to guide apprentices, journeymen, and contractors in learning easier and speedier methods of completing and cutting pattern layouts.

The third edition of **Oil Heating Handbook,** by Han A. Kunitz. Is said to be a practical guide on the installation, design, and use of moderate size oil heating equipment. Published by J. B. Lippincott Co., E. Washington Square, Philadelphia 5, Pa., the cloth-bound text contains 464 + x (5 x 7½ in.) pp. and is priced at $5.00.

Air Conditioning and Elements of Refrigeration, by Samuel P. Brown. Discusses heating and cooling load calculations, selection of equipment, and the design of air ducts and liquid piping systems. Containing 644 6½ x 9 in. pages, this cloth-bound text is published by McGraw-Hill Book Co., 330 W. 42nd St., New York City, and is priced at $6.00.

MEETINGS & CONVENTIONS

HPACCNA Secretaries and Board to Meet in Washington

The fall meeting of the secretaries' conference of the Heating, Piping and Air Conditioning Contractors National Association, 1250 Avenue of the Americas, New York 20, N. Y., will be held at the Hotel Statler, Washington, D. C., October 2 and 3, 1947.

The conference consists of secretaries or managers of state and local associations affiliated with the national association and it is held twice a year.

The board of directors of the national association will hold its fall meeting at the Washington Statler on October 3 and 4, 1947. A feature of the program will be a joint meeting with the secretaries on the afternoon of October 3.

AGA Members to Meet for 29th Annual Convention

The 29th annual convention of the American Gas Association, to be held October 6-8 in Cleveland, will include general sessions each morning with meetings of the sections and departments in the afternoon. Anticipating housing difficulties, the association has requested that reservations be made through E. C. Brennan, AGA housing secretary, 511 Terminal Tower, Cleveland 13, Ohio.

Sponsors Conference on Industrial Hydraulics

The third annual meeting of the National Conference on Industrial Hydraulics will be held October 16 and 17 at the Hotel Continental in Chicago. The conference is sponsored by Armour Research Foundation and the graduate school of Illinois Institute of Technology in cooperation with the Chicago sections of the SAE, ASCE, and ASME.

Additional information may be obtained from Dr. V. L. Streeter, Armour Research Foundation, Technology Center, Chicago 16, Ill.

AWS Plans Many Technical Sessions at Annual Meeting

The American Welding Society, 33 W. 39th St., New York City, has completed the tentative program for its 28th annual meeting to be held October 19-24 at the Hotel Sherman, Chicago, during the National Metal Exposition. A total of 70 papers covering 16 classifications of welding applications and research will be presented at the 20 technical sessions during the week.

In addition to the technical sessions of the Society there will be welding and cutting exhibits at the Exposition to be held at the International Amphitheatre, Chicago. This exposition, incidentally, has been extended to run a full week starting Saturday, October 18. It will be open from 12 noon to 10:30 p.m., October 18 to 22, inclusive, and from 10:00 a.m. to 6:00 p.m. on Thursday and Friday, October 23 and 24.

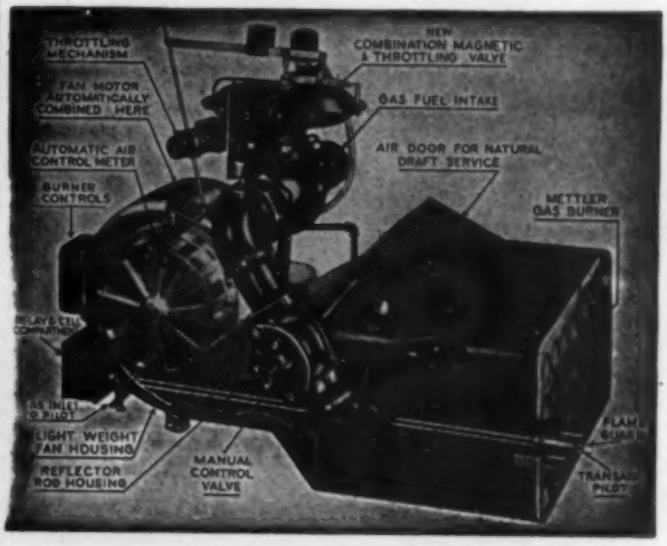
The session on pressure vessels to be held Tuesday morning, October 21, will include papers on Welding of Locomotive Type High Pressure Boilers, by G. M. Trefts, Farrar and Trefts, Inc.; Carbon Arc Welding

ENTRAINED COMBUSTION

The Mettler "FAN-AIR" Gas Burner

LATEST MODEL FEATURES NEW AUTOMATIC SAFETY PILOT and TRIPLE CONTROLS

HERE IS A "FRONT VIEW" OF FAN-AIR GAS BURNERS (COMPACT AND SIMPLE)



Lower picture reveals essential and highly desirable POINTS of FAN-AIR MECHANICAL DRAFT GAS BURNERS. Not just a gas burner but a COMPLETE AND FULLY AUTOMATIC BURNER SYSTEM, factory tested and ready for application when received. It comes to you complete as pictured with simple, dependable, automatic controls. No other burner so easy to install. Why be satisfied with less—when all these tangible advantages are so readily available. SIZES 5 TO 400 HP.

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LOS ANGELES 13 CALIFORNIA

of Copper Pressure Vessels, by J. J. Vreeland, Chase Brass & Copper Co.; Integral Cast Bosses for Pressure Vessels, by H. L. Anthony and H. P. Schane, Scaife Co., and Development of Butt-Welded Joints in Pressure Vessels, by E. J. Brown, Union Iron Works. The session on pipe welding scheduled for that afternoon will include papers on Tandem Electrode High-Speed Submerged Welding in 30 in. Gas Pipe, by C. A. Babbitt, Western Pipe & Steel Co., and Metallurgical Properties of High-Strength Seamless Line Pipe, by A. B. Wilder and J. D. Tyson, National Tube Co.

ACS Group Plans West Coast Chemical Show

An industrial chemical conference and display for western states and Pacific area are scheduled for the Civic Auditorium in San Francisco, Oct. 21-25. This is the first regularly scheduled Pacific Chemical Exposition and will be presented by the California section of the American Chemical Society, whose headquarters is at the Whitcomb hotel, San Francisco.

ASME Annual Meeting Scheduled for December

The 1947 annual meeting of The American Society of Mechanical Engineers, 29 W. 39th St., New York City, will be held at the Chalfonte and Haddon Hall hotels, Atlantic City, Dec. 1-5.

Other meetings scheduled for the remainder of the year include:

Petroleum mechanical engineering conference, Houston, Tex., Oct. 6-8.

Fuels division, joint meeting with the coal division of the AIMME, Cincinnati, Ohio, Oct. 20-22.

NARC Plans Activities During REMA Exposition

The 5th All Industry Refrigeration and Air Conditioning Exposition, to be held in Cleveland, January 26 to 29, is again being sponsored by the Refrigeration Equipment Manufacturers Association. Full cooperation with the 1948 show has been extended by the National Association of Refrigeration Contractors, which is planning special activities for this period. NARC's annual meeting, normally held in October, will be adjourned to some time during the week of the exposition when its headquarters will be set up in the Hotel Allerton in Cleveland. The second day of the show has been set aside for exclusive showings to contractors and service engineers.

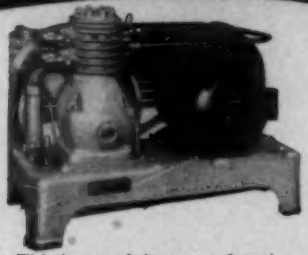
Heating, Air Conditioning Show to be Under Auspices of ASHVE

The 8th International Heating, Ventilating, and Air Conditioning Exposition will be held in Grand Central Palace, New York City, the week of February 2, 1948.

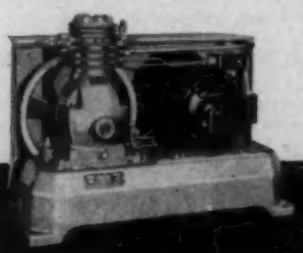
Exhibitors' response to date indicates that all space will be exhausted in advance of the opening, according to C. F. Roth of the International Exposition Co., Grand Central Palace, New York, N. Y., managers of the show.

The exposition will again be under the direct auspices of the ASHVE, and the Society's 54th annual meeting will be held concurrently.

This Could Be YOUR DOOR!



This is one of the types of equipment you could sell for us—1 HP air-cooled condensing unit—Methyl Chloride and Freon—12.



1½ HP water-cooled condensing units. Methyl Chloride and Freon—12.

Here is a real profitable opportunity for you if we have no sales and service representative in your locality and if you are able to qualify.

We are looking for adequately financed individuals or firms who have some experience in the air conditioning and commercial refrigeration fields. Personal integrity, enthusiasm, energy and a spirit of cooperative effort are factors that count heavily, as well as some knowledge of the market we would like to reach ..... and the various applications to which our equipment can be put. We have the finest engineered line in the industry ..... worthy of the finest type of representation. Lipman Machines are built in sizes ranging from ¼ to 40 horsepower, making it possible to obtain machines that are suited for all requirements. Designed to use Ammonia, Methyl Chloride and Freon refrigerants.

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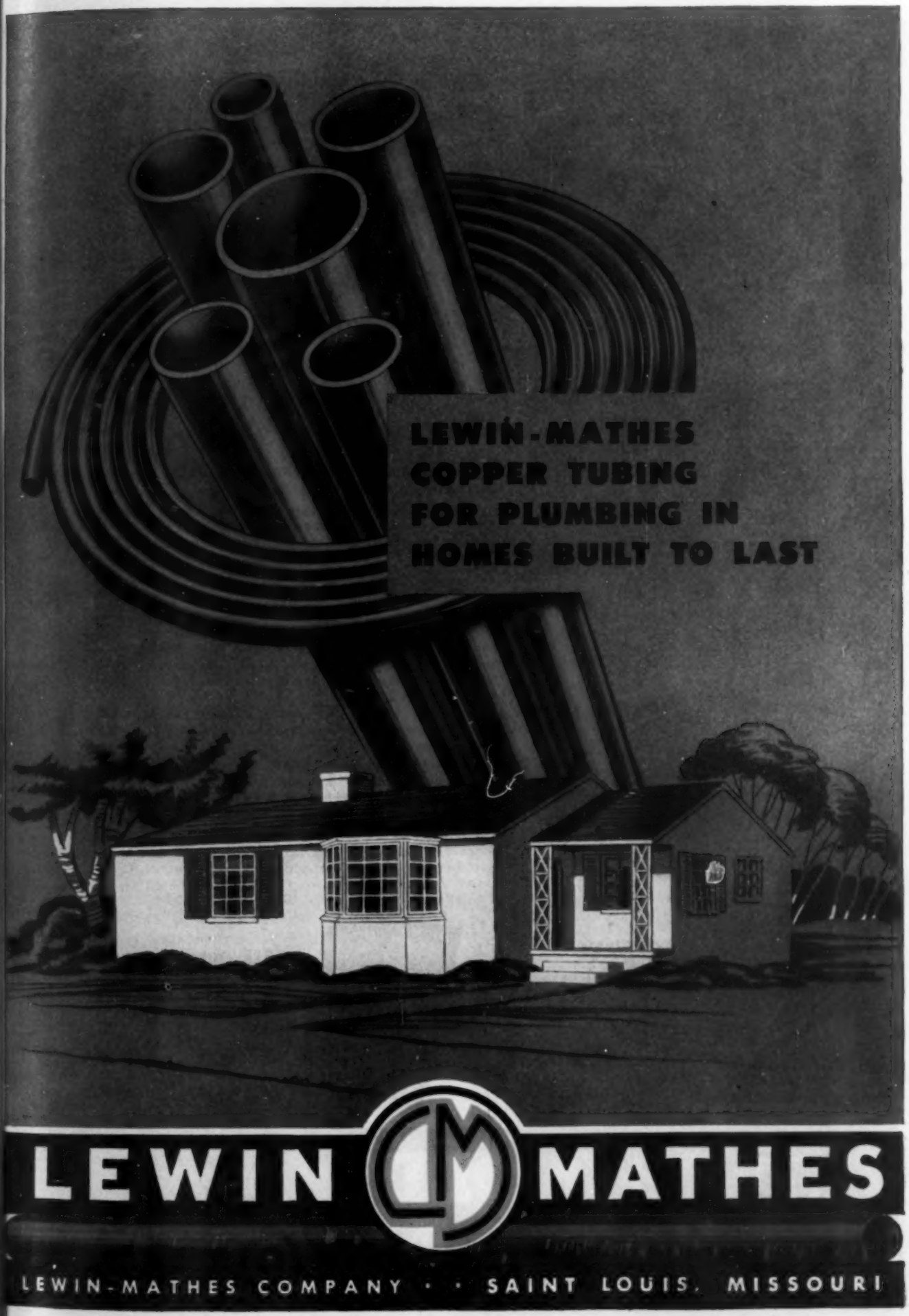
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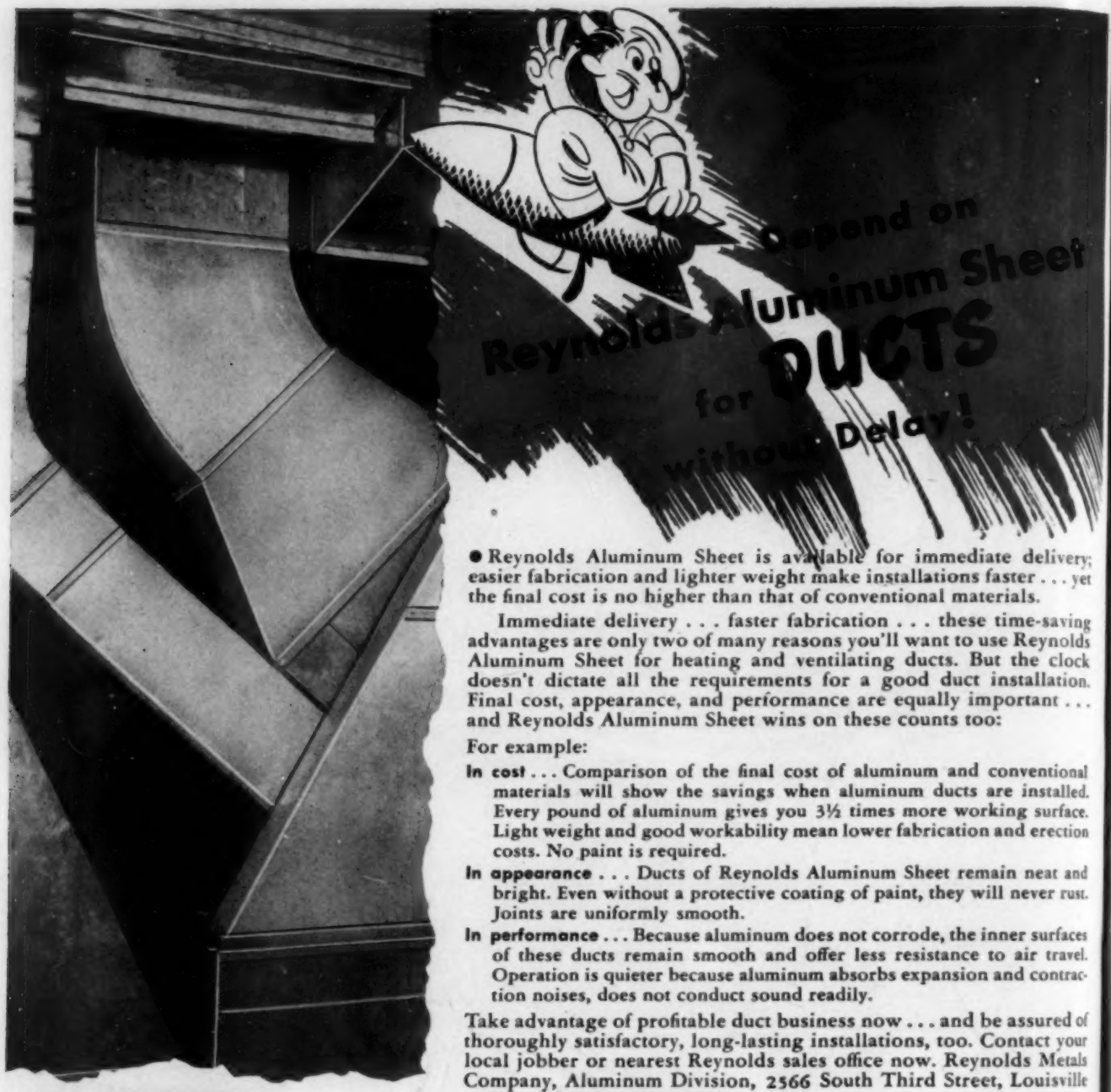
FOR PLUMBING IN
HOMES BUILT TO LAST
LEWIN MATHES
LEWIN-MATHES COMPANY · · SAINT LOUIS, MISSOURI



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Immediate delivery . . . faster fabrication . . . these time-saving advantages are only two of many reasons you'll want to use Reynolds Aluminum Sheet for heating and ventilating ducts. But the clock doesn't dictate all the requirements for a good duct installation. Final cost, appearance, and performance are equally important . . . and Reynolds Aluminum Sheet wins on these counts too:

For example:

In cost . . . Comparison of the final cost of aluminum and conventional materials will show the savings when aluminum ducts are installed. Every pound of aluminum gives you 3½ times more working surface. Light weight and good workability mean lower fabrication and erection costs. No paint is required.

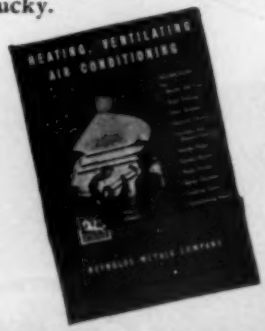
In appearance . . . Ducts of Reynolds Aluminum Sheet remain neat and bright. Even without a protective coating of paint, they will never rust. Joints are uniformly smooth.

In performance . . . Because aluminum does not corrode, the inner surfaces of these ducts remain smooth and offer less resistance to air travel. Operation is quieter because aluminum absorbs expansion and contraction noises, does not conduct sound readily.

Take advantage of profitable duct business now . . . and be assured of thoroughly satisfactory, long-lasting installations, too. Contact your local jobber or nearest Reynolds sales office now. Reynolds Metals Company, Aluminum Division, 2566 South Third Street, Louisville 1, Kentucky.

STRUCTURAL ANGLES

Structural Shapes for Duct Supports are available through your local jobber. Ask about the complete line of Aluminum Rivets, too.



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REYNOLDS *Lifetime* ALUMINUM

OHI Plans Convention and Exhibition in Chicago

The Oil-Heat Institute of America, 30 Rockefeller Plaza, New York City, is planning to hold a convention and exhibition of products at the Coliseum in Chicago, the week of April 5, 1948.

To Expand Program for Indoor Comfort Conferences

The popular heating schools, known as Indoor Comfort Conferences, which have been conducted by the National Warm Air Heating and Air Conditioning Association, 145 Public Square, Cleveland, will not only be continued in 1948 but will be expanded to increase each conference to three days and to include warm air systems in commercial and other large buildings and panel heating systems using warm air ceiling panels.

A nominal tuition fee is charged each person attending the schools to partially defray the cost of operating this program which is designed to offer practical information and basic fundamentals for designing, installing, and servicing both gravity and forced warm air heating systems.

HPACCNA Selects Pittsburgh for Meeting

The Heating, Piping and Air Conditioning Contractors National Association, Rockefeller Center, 1250 Avenue of the Americas, New York City, has chosen Pittsburgh as its convention city for 1948. The association's 59th annual convention will be held June 1-5 at the Hotel William Penn.

ASTM Announces Meetings

The American Society for Testing Materials, 1916 Race St., Philadelphia, has announced that the 1948 annual meeting will be held in Detroit during the week of June 21-25 and in conjunction with this will be the Eighth Exhibit of Testing Apparatus and Related Equipment. Several Detroit hotels will cooperate, but headquarters will be at the Book-Cadillac. The 1948 committee week and spring meeting will be held in Washington, D. C., during the week of March 1-5. In addition, a number of ASTM technical committees will either hold group sessions separately or may combine with other committees in the same fields for three or four-day meetings in the fall or spring. While official announcement has not yet been made, it is quite definite that the 1949 annual meeting will be in Atlantic City.

A contest to discover the oldest installations of 85 per cent magnesia insulation still functioning efficiently has been announced by the Magnesia Manufacturers Association. First prize in the contest, which closes October 10th, is a $100 Savings Bond. Fifteen other prizes are also being offered, and entry blanks may be obtained from the association at 1317 F St., N. W., Washington 4, D. C.

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HEATING AND AIR CONDITIONING PRODUCTS

BLAST HEATING COILS—AIR CONDITIONING COILS—ALL TYPES

All copper spiral fin tube construction with the tubes formed or bent permits uniform expansion without strain. Headers are heavy wall construction with tubes brazed into extended ferrules formed in the headers. Fins are helically wound and metallically bonded. May we send catalog?

VERTICAL TYPE UNIT HEATERS

A proven heating unit, modern in design, incorporating every unit heater advancement. McCord copper spiral fin tube construction creates air turbulence without undue restriction. Improved fan blades deliver large volume of air with minimum air noise. Guaranteed for 150 lbs. saturated steam pressure. Specify McCord.

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A time proven heating unit, modern streamlined in design, quiet, yet its rugged construction adapts it to all types of installations, guaranteed for use on No. 150 p. s. i. steam pressure. All copper heating element, individual spiral fin tubes free to expand without strain on joints. Standard motors with standard bases used. Wide range of capacities.

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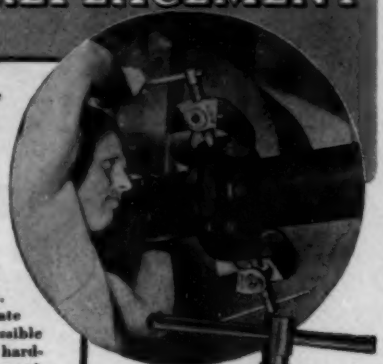
FAST • SAFE • EASY
GASKET REPLACEMENT



The only tool that takes the guesswork out of replacing gaskets, regardless of location. Flanges are parted quickly and held in perfect alignment without damage to faces . . . shock and jarring of pipe lines are eliminated . . . there is no danger from flying wedges . . . no sparks caused by hammer blows. FLANGE-JACKS eliminate costly shutdowns, make possible fast, economical repairs in hard-to-get-at locations, offer maximum safety.

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Automatic Equipment for Pressure and Level Control

No. 6622—The "Kontrol Motor" line of pressure regulators and diaphragm motor valves is described in a new catalog (No. 47) released by Kieley & Mueller, Inc., 2033 43rd St., North Bergen, N. J. Running well over 100 pages, the booklet is made up of five sections covering, in addition to diaphragm valves, the company's lines of liquid level controllers, strainers, pressure reducing and regulating valves, pump governors, and such steam plant equipment as back pressure valves, atmospheric relief valves, diaphragm relief valves, oil and grease extractors, and exhaust heads. Particular emphasis has been given to dimension and weight tables. Data to be given when ordering are outlined in detail for each type of equipment. While no general distribution of the catalog is planned, copies are available for steam plant and process industry engineers, designers, and purchasing personnel.

HAYES DUCT FURNACE

STAINLESS STEEL HEAT EXCHANGER

The Hayes SED-E model (end service illustrated) is a gas fired unit designed to be installed into and become a section of a duct system, similar to heating coils. Also made in side service.

Constructed of Type 321 *Stainless* Steel. Can be installed down stream of cooling coils, making it unnecessary to drain refrigerant on the heating cycle.

May be installed in banks, for large BTU requirements.

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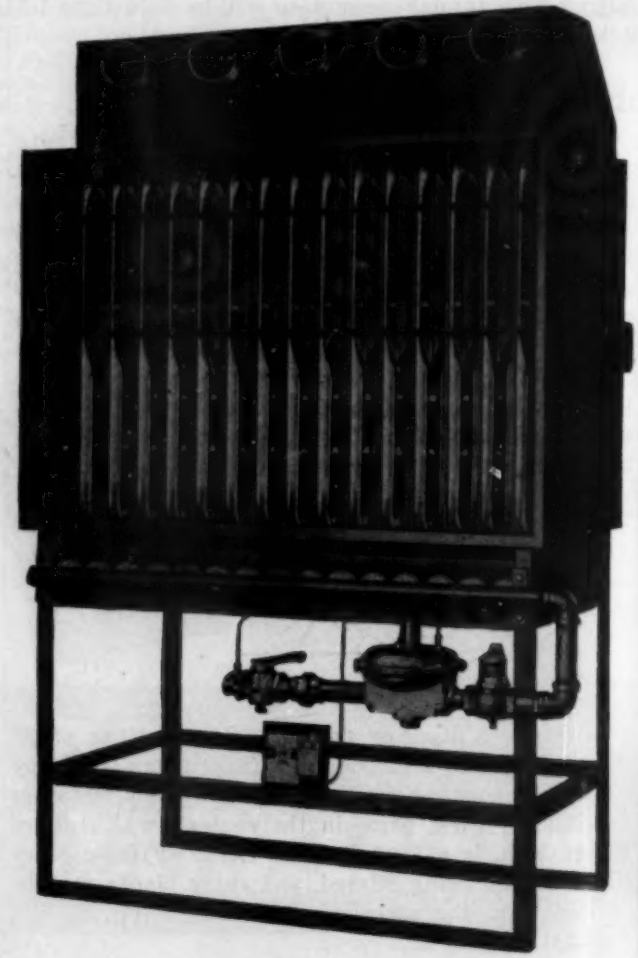

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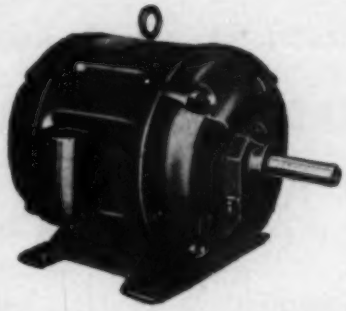
Heating, ventilating, and air conditioning has become a tremendous industry and Wagner engineers have played an important part in its development. Today, hundreds of thousands of Wagner Quality Motors are providing dependable, quiet, troublefree power. Users of Wagner motors also profit by our quick, convenient, nationwide service facilities.

Twenty-nine branch offices, located in principal cities are ready to give you service. They can help you solve all of your motor problems. Write for Bulletin MU-185, addressing Wagner Electric Corporation, 6370 Plymouth Avenue, St. Louis 14, Mo.



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